DOCUMENT RESUME

ED 285 772 SE 048 360

AUTHOR	Kloosterman, Peter; Harty, Harold
TITLE	Current Teaching Practices in Science and Mathematics in Indiana Elementary Schools. Final Report.
INSTITUTION	Indiana Univ., Bloomington. School of Education.
SPONS AGENCY	Indiana State Dept. of Education, Indianapolis.
PUB DATE	Aug 87
NOTE	84p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Computer Assisted Instruction; Computer Uses in Education; Drills (Practice); Elementary Education; *Elementary School Mathematics; *Elementary School Science; Experiential Learning; Manipulative Materials; Mathematics Education; *Mathematics Instruction; *Problem Solving; Science Education; *Science Instruction; *State Surveys; Teaching Methods
IDENTIFIERS	*Indiana

ABSTRACT

In December of 1986 and January of 1987, questionnaires on teaching practices in science and mathematics were sent to elementary school principals in Indiana. The first questionnaire, completed by 301 administrators, concerned manipulative use of materials in science and mathematics. The second questionnaire, completed by 317 administrators, contained questions dealing with problem-solving instruction and use of computers in science and mathematics. Results of the study include findings that: (1) manipulatives were used to teach science more frequently in grades 3-5 than in grades K-2; (2) manipulatives were used to teach mathematics more frequently in grades K-2 than in grades 3-5; (3) problem-solving was given greater emphasis in grades 3-5 than in grades K-2 in science and mathematics; (4) computers were used for science and mathematics instruction more in grades 3-5 than in grades K-2, and (5) drill and practice was the most common application of the computer to science and mathematics instruction. Tables are provided in the text; copies of the questionnaires are included in the appendix. (Author/TW)

Final Report

CURRENT TEACHING PRACTICES IN SCIENCE AND MATHEMATICS IN INDIANA ELEMENTARY SCHOOLS

Project Co-Investigators

Peter Kloosterman
Harold Harty

Project Assistant

Jack Matkin

Project Associate

Don Small

Project Support Staff
Ann Fischer
Debra Woodward

School of Education
Indiana University
Bloomington, Indiana

August, 1987

This project has been supported in part by a grant from the Indiana Department of Education. The opinions and conclusions expressed in this document do not necessarily reflect the position or policy of the Indiana Department of Education and no official endorsement should be inferred.

CURRENT TEACHING PRACTICES IN SCIENCE AND MATHEMATICS IN INDIANA ELEMENTARY SCHOOLS

Abstract

In December of 1986 and January of 1987, questionnaires on teaching practices in science and mathematics were sent to elementary school principals across the State of Indiana. The first questionnaire, completed by 301 administrators, concerned manipulative use in science and mathematics. The second questionnaire, completed by 317 administrators, contained questions dealing with problem-solving instruction and computer usage in science and mathematics. Results of the study include findings that: (a) manipulatives were used to teach science more frequently in grades 3-5 than in grades K-2, (b) manipulatives were used to teach mathematics more frequently in grades K-2 than in grades 3-5, (c) problem-solving was given greater emphasis in grades 3-5 than in grades K-2 in science and mathematics, (d) computers were used for science and mathematics instruction more in grades 3-5 than in grades K-2, and (e) drill and practice was the most common application of the computer to science and mathematics instruction. Copies of the questionnaires are included in the report.

Table of Contents

Tables

Introduction

Early in 1986, Harold Harty and Peter Kloosterman from Indiana University were completing a study on an expected shortage of mathematics and science teachers at the secondary level in Indiana. Surprisingly, that study indicated no major shortage of high school teachers in those fields (Kloosterman & Harty, 1986). Based on that finding, it was decided that improvement in mathematics and science training in Indiana might be needed more at the elementary rather than the secondary level. Data on mathematics and science instruction at the elementary level were, however, incomplete. Harty and Kloosterman spoke with Don Small, executive director of the Indiana Association of Elementary and Middle School Principals, and with Jerry Colglazier of the Indiana Department of Education about the possibility of collecting data on mathematics and science instruction at the elementary level throughout Indiana. Based on those discussions, Harty, Kloosterman, and Small submitted a research proposal to the Indiana Department of Education on March 12, 1986. The proposal and budget were approved by the Department of Education but unavoidable delays made it impossible to collect data in May of 1986 as was the original plan. The timeline for the project was rewritten in a revised proposal so that data were collected in the fall and winter of 1986. Financial resources, while remaining at the same funding level as the original proposal, were reallocated in the revised proposal to allow hiring of a graduate student (Jack Matkin) to aid in the data collection and analyses. Funding on the project was set to expire in May of 1987 but teaching schedules and other commitments forced extension of the funding expiration date to June 15, 1987. This final report was written in June, July, and early August of 1987.

Background Information

Manipulatives

The use of manipulatives in the teaching of elementary school has been advocated for a number of years. Fennema (1972) stated that concrete models, when used appropriately, make meaningful learning of ideas more likely. Suydam and Higgins (1977) reviewed studies involving manipulative use in mathematics and concluded that using manipulative materials over a period of time is likely to improve student achievement in mathematics. Parham (1983) used meta-analytic techniques on data from 64 studies to again conclude that manipulative instruction in was superior to non-manipulative instruction in most instances. Post (1980) noted that textbooks, by their two-dimensional nature, cannot provide the concrete experiences students need to gain initial understanding of concepts. Herbert (1985) spoke of the motivational advantages of using manipulatives to teach mathematics. The introduction of calculators and computers into our society, has, if anything, increased the importance of using concrete manipulatives in the teaching of mathematics (Impact of Computing, 1985).

While the research studies and summaries cited above indicate that use of manipulatives generally results in increased achievement as compared to non-manipulative instruction, it is also clear that when manipulatives are not appropriately related to abstract ideas, their use may be of little value (Fennema, 1972; Heddens, 1986; Post 1980; Suydam & Higgins, 1977). Larson and Slaughter (1984) looked at teacher use of manipulatives in nine classrooms and found that teachers often failed to relate concrete models to mathematical equations and algorithms. Students in those classes were having a hard time making associations between concrete, pictoral, and symbolic representations of mathematical concepts. The issue of whether grade level should be a factor in using manipulatives is also important. Manipulatives appear to be used more often in primary as opposed to intermediate grades under the assumption that younger children need more hands-on experiences (Leeb-Lundberg, 1985; Suydam, 1984). Herbert (1985), however, speaks of the benefits of using manipulatives with middle school students.

Despite the importance of manipulatives in teaching, data concerning manipulative use in elementary school classrooms are incomplete and out of date. Reporting on surveys from the mid-1970s, Fey (1979) noted that of the K-6 teachers studied, nearly half reported that their students used manipulatives less than once a week if at all. Clearly, some teachers, such as those using the manipulative-oriented Mathematics Their Way text (Baratta-Lorton, 1976) use manipulatives frequently and effectively in the teaching of mathematics. Many other teachers, however, appear to use manipulatives little if at all. The current study was designed to assess the extent of manipulative use across a large sample of schools. General questions addressed by the study included the extent to which teachers had manipulatives available to them, how often teachers used manipulatives, whether manipulatives were used more frequently in the primary or the intermediate grades, and whether manipulatives were used more for building computational skills or for promoting understanding of broad concepts.

Problem Solving

The teaching of problem solving has been noted, in recent years, as the key to good instruction. The Agenda for Action published by the National

Council of Teachers of Mathematics in 1980 began with the recommendation that "problem solving should be the focus of school mathematics in the 1980s" (p.1). As we move toward the close of the 1980s, that recommendation is a goal which has yet to be accomplished. We are, however, much closer to achieving the goal than was the case several years ago. Virtually all mathematics textbooks being sold for use in elementary and secondary schools claim to teach problem solving. A variety of supplemental materials such as the Problem-Solving Experiences in Mathematics series (Charles & Lester, 1985) and the Problem-Solving Sourcebook series (Nibbelink & Shepardson, 1985) are available to aid in the teaching of problem solving in elementary and middle schools. Knowledge about evaluating student progress in problem solving is becoming much more plentiful as evidenced by the recent publication of How to Evaluate Progress in Problem Solving (Charles, Lester, & O'Daffer, 1987).

Unfortunately, not all problem-solving materials in texts are as well written as they could be. In addition, even good problem-solving materials do not necessarily insure problem-solving instruction. Commitment of teachers and principals to making problem solving the focus of school instruction is essential if problem solving is to become an integral part of the curriculum. This is particularly true in the elementary school where many individuals still seem to see mathematics instruction as Stake and Easley (1978) found it ten years ago, primarily devoted to helping children learn to compute. The third mathematics assessment of the National Assessment of Educational Progress found little change in the mathematics proficiency of nine-year-old children between 1973 and 1982 (Carpenter, Matthews, Lindquist, and Silver, 1984). Some improvement took place for thirteen-year-old students during that period but the improvement was on computational items. Problem-solving performance was poor and relatively stable for both age groups studied throughout that period (Carpenter et al., 1984). It is hoped that data from the fourth national assessment will be more positive but the overall picture is clear, elementary school students are not consistently being taught to be good problem solvers.

While acceptance of problem solving as the primary goal of school instruction seems to be gaining in popularity at a modest pace, the need for the goal is as strong as ever. Some degree of computational skill is important for children, yet computers and calculators have made the need for students to be fast and accurate at computations obsolete (Impact of Computing, 1985; Williams, 1987). As deciding which concepts must be applied to solve a problem is a that task computers and calculators cannot perform, developing the problem-solving skills of elementary school students is the obvious goal to replace excessive proficiency at computation (Osborne & Kasten, 1980).

The purpose of the study reported here was to determine the extent to which problem-solving and critical-thinking skills were becoming an integral part of the curriculum of elementary schools. As has been noted, problem-solving skill should be the first and foremost goal of mathematics instruction at all grade levels, yet in many instances the myth that problem-solving instruction can come only after computational skills are developed still prevails. Particular attention was given to the issue of whether or not problem solving was taught more frequently in the upper as opposed to lower elementary grades.

Computers

Computers are rapidly becoming a part of elementary school education throughout much of the United St-tes. Becker (1986) reported that the majority of U.S. elementary schools had five or more computers. The extent to which computers are actually used in elementary schools varies as evidenced by a survey of elementary school teachers in Fort Worth that indicated 79% never used computers (Seidman, 1986). In a South Carolina study, Dickey and Kherlopian (1987) found 70% of the elementary mathematics and science teachers they surveyed had access to computers but only 43% actually used them. Kloosterman, Ault, and Harty (1987) noted a variety of computer uses in elementary schools where substantial effort had been put into using computers. While computers can be used in many ways to teach almost any subject, a majority of teachers in elementary schools feel the best use of computers is for computer assisted instruction (Be ker, 1986). Indeed, computer assisted instruction means using the computer to teach academic content to students and thus computer assisted instruction should be the focus of inquiry when computer utilization to teach elementary school mathematics is being studied.

Computer assisted instruction (CAI) has been divided into various classifications by different authors. The predominant use of CAI has been drill and practice (Elron, 1983; Long, 1985). Ninety-four percent of the elementary teachers surveyed by Dickey and Kherlopian (1987) who used software indicated they used drill and practice with their students. Despite an introduction to programming and other types of software, elementary teachers in an inservice computer course chose to complete drill and practice rather than other types of projects for teaching mathematics to students (Ponte, Norman, Davis, Eshun & Jensen, 1986).

While drill and practice is the most common type of software used in teaching elementary school mathematics and science, tutorial, simulation and problem solving software are also used (Glass, 1984; Hatfield, 1984; Heck, Johnson & Kansky 1981). Fifty-six percent of the computer-using elementary teachers in the Dickey and Kherlopian (1987) study used tutorials, 19% used simulations, and 38% used software designed to promote problem solving. Eiser (1986) has noted that what is called problem-solving software can involve a variety of skills but many of these are skills such as finding geometric or numeric patterns and breaking a task into manageable parts are important goals of elementary mathematics instruction which are seldom met (Carpenter, Matthews, Lindquist, & Silver, 1984). In general, simulation and problem solving software force students into much more complex thought than is necessary for drill and practice programs (Elron, 1983; Fuller, 1986; Norton, 1985).

As has been discussed, the potential and actual uses of computers for mathematics and science instruction are varied. Effective use of computers in elementary school instruction has, however, been continually recommended. The Agenda for Action, published by the National Council of Teachers of Mathematics (NCTM) in 1980, recommended that mathematics programs take full advantage of the power of computers at all grade levels. That recommendation was affirmed at a 1984 NCTM conference on using computers in mathematics instruction (Impact of Computing, 1985). NCTM published its 1984 yearbook (Hansen, 1984) on computers to promote their use. A conference sponsored by NCTM and the U.S. Department of Education proposed a task force to help make computer courseware compatible with curriculum guidelines for teaching mathematics (Romberg, 1984). Since 1985, elementary school mathematics texts have included computer activities (Westly, 1985). In short, the issue of computer use in elementary school instruction is not one of "if" but rather one of "when" and "how". While any survey of computer use is out of date almost as soon as it is published, the survey reported here is an attempt to determine, as of late 1986, the extent and type of computer use for the teaching of mathematics and science in Indiana elementary schools.

Method

To determine the extent to which manipulative materials, problem solving/critical thinking, and computers are impacting elementary school mathematics and science instruction in Indiana, two questionnaires were designed, validated and then mailed to elementary school principals throughout the state. Details on the sample and data collection procedures will be presented after explanation of the instruments.

Instruments

Questions concerning manipulatives, problem solving, computers, and inservice needs were written and arranged into two sets, one for each of the two questionnaires. Two questionnaires were used to keep the time necessary to complete the instruments to a minimum. Questions on the first instrument centered around the use of manipulative materials in elementary school classrooms. Questions on the second instrument centered around the issues of problem solving/critical thinking, computers, and inservice needs. Each question had a mu tiple response format for which the respondent had only to choose the best response. For each question, the respondent was to provide four separate answers, one for each of the subcategories of: (a) mathematics in grades K through 2, (b) mathematics in grades 3 through 5, (c) science in grades K through 2, and (d) science in grades 3 through 5. Responses were to be generalizations or averages for all teachers in a school. A space for comments was added to the end of each questionnaire. Copies of both instruments and cover letters accompanying those instruments are included in Appendix A (Indiana Statewide Elementary School Math and Science Needs Assessment Inventories).

<u>Content Validation</u>. Both questionnaires were presented to a validation panel for reaction concerning the importance of the questions and the ability of elementary school principals to adequately respond to the questions. Members of the panel who reacted to the questions included college professors and graduate students in mathematics, science, and elementary education; elementary school principals, and elementary school teachers. In general, most of these individuals were very positive about the items as written although minor modifications to the questions were made based on suggestions from this group.

In addition to suggestions for revision, the content validation panel was asked to rate, on a five choice Likert-type scale, the items on the questionnaires. Validation scale rating categories were: (a) representativeness of the items from the total pool or universe of items dealing with use of manipulatives, (b) degree of congruence between the substance of the items and the underlying construct, (c) degree of clarity of the items for elementary school principals, (d) potential for the findings to impact teacher training and curriculum development, and (e) degree of overall usefulness of knowledge production from the study. A Scott's coefficient of interrater agreement (Scott, 1955) was calculated across the five validation dimensions. The coefficient computed for the mathematics items was 0.73. The coefficient computed for the science items was 0.86. These coefficients indicate respectable construct validation for the instruments.

<u>Test-Retest Reliability</u>. Test-retest reliability is the degree to which individuals give consistent responses to an instrument over time. High test-retest reliability on an instrument is an indication that the instrument

is measuring well formulated knowledge or opinions rather than momentary thoughts. Test-retest reliability was computed for the instruments used in this study by having seven doctoral level graduate students with teaching or administrative experience respond to the instruments with respect to their most recent elementary school experiences. The students were asked to complete the instruments again five weeks later. A test-retest reliability coefficient was calculated at 0.67 ($p<.05$) for mathematics and 0.93 ($p<.05$) for science using the Spearman correlation technique. These coefficients were high enough to insure that responses to the questions were stable over time.

Instrument A: Manipulatives. Questions on the first instrument and rationale for asking those questions were as follows.

A1. What percentage of your teachers have commercially made "hands-on" materials/manipulatives/physical models available for use in your school?

Examples given for mathematics were base-ten blocks, Cuisenaire rods, attribute blocks, and pattern blocks. For science, examples were thermometers, balances, candles, and live specimens. The five possible responses for each subcategory (math K-2, math 3-5, science K-2 and science 3-5) were: (1) less than 10%, (2) 10% to 39%, (3) 40% to 60%, (4) 61% to 89%, and (5) 90% to 100%.

A2. What percentage of your teachers have teacher-made or teacher-collected "hands-on" materials/manipulative/physical models available for use in your school?

Examples given for mathematics were counting sticks, bead sticks, blocks, buttons, and cardboard shapes. For science, examples were leaf collections, tin cans, insect collections, jars, rock collections, rope, and paper bags. Response options for question A2 were the same as those for question A1.

The rationale for including questions A1 and A2 in the survey was that no large scale data sets are available which document the extent to which hands-on materials can be found in elementary school classrooms. It is entirely possible that lack of material use may result in part from lack of materials. Hands-on and teacher-made materials were distinguished in questions one and two on the assumption that teacher-made materials would be less expensive and therefore more readily available in most schools.

A3. About how many days per school year do pupils use "hands-on" materials/manipulatives/physical models (commercial or teacher-made)?

Response categories for item A3 were: (1) less than 10, (2) 10 to 21, (3) 22 to 41, (4) 42 to 89, and (5) 90 or more. As this question was quite straightforward, no illustrative examples were given.

A4. When "hands-on" materials/manipulatives/physical models (commercial or teacher-made) are used in the classroom, to what extent are they used to help pupils "learn the rules" for computation, measuring, estimating, etc. rather than understand how or why these rules work?

Response categories were: (0) unable to answer, (1) not used at all, (2) rarely, once in a great while, (3) sometimes but not often, (4) often but not always, (5) most if not all of the time. Mathematics examples given for question A4 were that manipulatives could be used to increase speed for computations, memorize basic facts, or learn definitions. Science examples for question A4 were to use manipulatives to learn the rules for graphing, operationally defining, variable identification, or classification.

A5. When "hands-on" materials/manipulatives/physical models (commercial or teacher-made) are used in the classroom, to what extent are they used to get pupils to understand broad concepts or to solve problems which require substantial creative thinking?

Response options for question A5 were the same as those for question A4. Mathematics examples provided were that manipulatives could be used to understand computational procedures, understand multi-step story problems, apply computations to real life problems, understand pattern questions, or to solve logic problems. Science examples were materials used for explaining inductive and deductive approaches, setting up controlled experiments, and doing science fair projects.

The rationale for including questions A4 and A5 was that manipulative materials may not aid learning in classrooms where they are used in ways other than those specified by materials developers. Mathematical materials are usually intended to help children understand broad mathematical concepts such as place value although they can be used to foster simple skills such as counting. In science, students need to learn how to use materials such as thermometers and balances before they are able to use the materials for more complex tasks such as setting up controlled experiments.

A6. How much did (will) your school look for texts that use "hands-on" materials/manipulatives/physical models in your most recent (current) textbook selection?

Response options for question A6 were: (0) unable to answer, (1) was not a factor, (2) considered occasionally, (3) considered often, (4) considered extensively, and (5) was the main factor.

Question A6 was included as mathematics textbooks had been adopted statewide six months before this survey was sent out and science textbooks were being considered for adoption the year the survey was sent. Text decisions in the elementary school are very important because of the expense involved as well as the fact the text selection does not take place again for 7 years. Thus school personnel that felt manipulative materials were important factors in text selection probably had more of a commitment to the use of such materials than did those who did not feel manipulative materials were an important factor in text selection.

A7. On the average, how many <u>minutes per week</u> are devoted to the "hands-on" teaching of science and mathematics in each classroom?

Response options for question A7 were: (1) none, (2) 1 to 59 minutes, (3) 60 to 119 minutes, (4) 120 to 240 minutes, and (5) more than 240 minutes.

A8. On the average, how many <u>minutes per week</u> are devoted to the "non-hands-on" teaching of science and mathematics in each classroom?

Included in the questionnaire was a note that "non-hands-on" teaching was to include all teaching except hands-on. Response options for question A8 were the same as those for question A7.

Questions A7 and A8 were included in the questionnaire to determine the extent to which mathematics and science are taught in Indiana elementary schools and to get a general picture of the amount the amount of class time devoted to manipulative as opposed to non-manipulative activities.

Instrument B: Problem Solving, Computer Use, and Inservice Needs. The questions included as part of the second questionnaire focused on problem solving/critical thinking skills, computer use, and inservice opportunities for teachers. The questions and rationales for asking those questions are as follows.

B1. To what extent is your curriculum geared toward problem solving and understanding of broad concepts as opposed to "following the rules" to complete a computation or get an answer to a science question? An emphasis on problem solving and the understanding of broad concepts exists:

Response options were: (0) unable to answer, (1) practically never, (2) once in a great while, (3) sometimes, (4) fairly often, and (5) very often. To aid in understanding the question, examples were included from mathematics and science. The mathematics examples of problem solving and broad concepts were understanding of place value and multi-step story problems, applying math to real life problems, and solving logic problems. The science examples were understanding concepts such as cell, wind, autumn, and sound.

B2. Approximately how many minutes per week do students spend on activities designed to foster "higher level" thinking skills?

Response options were: (0) unable to answer, (1) none, (2) 1 to 59 minutes, (3) 60 to 119 minutes, (4) 120 to 240 minutes, and (5) more than 240 minutes. Examples of higher level thinking skills given for mathematics were applying math concepts to new situations, solving pattern problems, and understanding of fractional parts. Examples given for science were applying science concepts to new situations, learning about inductive and deductive approaches, and creating controlled experiments.

Questions B1 and B2 were included in the questionnaire to obtain general information about the extent to which problem solving and critical thinking are taught in elementary schools. Question B1 dealt with the goals of the school curriculum while question B2 was intended to provide a picture of the extent to which teachers worked to achieve the goal of increasing critical thinking skills on the part of students.

B3. How often do teachers bring in activities beyond those found in the textbook that promote problem solving and the development of "higher order" thinking skills?

Response options for question B3 were: (0) unable to answer, (1) almost never, (2) one to three times per month, (3) four to six times per month, (4) seven to nine times per month, and (5) ten or more times per month.

B4. How much of a factor were (are) the teaching of problem solving and promoting the development of thinking skills in your most recent (current) textbook selection?

Response options for question B4 were: (0) unable to answer, (1) were not factors, (2) considered occasionally, (3) considered often, (4) considered extensively, and (5) were the main factors.

Questions B3 and B4 were included as proxies for teacher and school commitment to the goals of developing problem solving and critical thinking skills in the elementary school. Teachers who provide supplemental problem solving activities, as suggested in question B3, have shown commitment to developing higher order thinking skills. Schools and teachers that have looked for texts that promote problem solving and critical thinking, as assessed in question B4, have shown commitment to teaching these skills and thus these questions were deemed appropriate.

The next questions on Instrument B dealt with the issue of computer use for instruction in mathematics and science. Computer use was divided into the four categories of (a) drill and practice, (b) tutorial, (c) simulation, and (d) problem solving/critical thinking. The format of this question varies from that of other questions as the respondent was asked to specify the amount of computer use in each of the four categories. To make explanation of the results of the computer question easier, it will be treated as four separate questions, numbers B5 to B8.

B5. How many minutes per week will an average pupil use the computer (alone or in a small group) to practice previously learned material?

B6. How many minutes per week will an average pupil use the computer (alone or in a small group) to learn <u>new</u> information or subject matter?

B7. How many minutes per week will an average pupil use the computer (alone or in a small group) to learn by way of a computer simulation?

B8. How many minutes per week will an average pupil use the computer (alone or in a small group) to attempt to develop problem-solving and/or higher-order thinking skills?

Response options were: (1) not at all, (2) 1 to 30 minutes, (3) 31 to 60 minutes, (4) 61 to 120 minutes, and (5) more than 120 minutes. For category 3 (simulations) clarifying examples were included. The mathematics examples were "operate" a lemonade stand and "run" a store. The science examples were flow of a drop of blood in the human body, life cycle of a frog, and reproduction of a cell.

The final question on Instrument B aimed at administrative commitment to teaching problem solving/critical thinking and to the use of computers by asking about availability of teacher inservice on these issues. To make explanation of the results of this question easier, it has been treated as two separate questions, numbers B9 and B10.

B9. Inservice training/preparation is available to teachers on hands-on manipulatives and/or problem solving:

B10. Inservice training/preparation is available to teachers on computer assisted or managed instruction:

Response options questions B9 and B10 were (1) less than once every two years, (2) once every two years, (3) once a year, (4) once a semester, and (5) two or more times per semester.

Sample

Elementary school principals were chosen to respond to the questionnaires as it was expected they would be the individuals with the best overall picture of instructional practice within a given elementary school. As this study was done in cooperation with the elementary and middle school principals' association of Indiana, members of the association constituted the main body of the sample. Approximately 65% of the public elementary principals in the state are members of the association. Many of the private elementary school principals in the state are also members of the association although private schools teach less than 10% of Indiana's students in grades K-12. The membership list of the principals association was divided into two groups with all odd numbered members receiving instrument A and all even numbered members receiving instrument B. Members of the association who were not active elementary school principals (e.g. curriculum supervisors, middle school principals) were not included in the sample. In addition to members of the association, each form of the questionnaire was sent to 50 randomly selected public elementary school principals in the state who were not members of the association. Using this sampling methodology, instrument A (hands-on manipulatives) was sent to 421 principals and instrument B (problem solving, computers, and inservice) was sent to 414 principals.

Procedure

Questionnaires and postage paid return envelopes were mailed late in the fall of 1986. Accompanying each questionnaire was a cover letter signed by the State Superintendent of Public Instruction along with the principal investigators of the study (Appendix A: Indiana Statewide Elementary School Math and Science Needs Assessment Inventories). Instructions for completing the instrument were included in the cover letter and on the instrument itself. Included in the instructions was assurance of confidentiality of results. A second mailing of the instrument to those who had not returned it took place in January, 1987.

Instructions in the cover letter included a return date and examples of manipulatives (Instrument A) or problem solving (Instrument B). The instructions for Instrument A included a statement noting that questions concerning the use of hands-on manipulatives should be answered with respect to student use of the materials. A teacher who used manipulatives to demonstrate but did not allow the students to use the manipulatives themselves was, for the purposes of the survey, not to be considered using manipulatives in her/his classroom. Detail on the definition of problem solving/critical thinking skills was provided in the instructions for Instrument B.

In addition to definitions of manipulatives or problem solving, cover letters for the instruments noted that responses to the items should be indicative of the average or typical teacher in the school. It was suggested that the principal pole his or her teachers or ask teachers for help in completing the questionnaire to provide an accurate picture of practice in the school.

Data from the questionnaires were tabulated by computer. Frequencies, means, and standard deviations were calculated for each part of each question. T-tests were used to determine significant differences in responses between questions. A probability level of $p<.01$ was used to determine statistical significance for the study.

Results and Specific Conclusions

After two mailings, 301 (71%) of the manipulatives questionnaires (Instrument A) were returned. Eighty-one percent of these were completed by principals alone, 2% were completed by teachers and principals together, 6% were completed by one or more teachers without input from the principal, and 11% were completed by some other individual or group. A one-way analysis of variance performed by respondent group for each question revealed a statistically significant difference (p>.05) on only the K-2 level response on one of the eight questions and thus responses for the groups were pooled. In addition, a t-test indicated there was no statistically significant difference (p>.05) between responses of members and non-members of the principals' association and thus responses of these groups were also pooled.

Return rate for the problem solving/computer use questionnaire (Instrument B) was very similar to that of the manipulatives questionnaire. Three hundred and seventeen (76%) of the questionnaires were returned. Seventy-six percent of these were completed by principals alone, 5% were completed by teachers and principals together, 10% were completed by one or more teachers without input from the principal, and 9% were completed by some other individual or group. There were statistically significant differences between responses of principals and non-principals at one grade level for two questions. There were no statistically significant differences between members and non-members of the principals' association. Thus, responses were pooled across groups for each question on Instrument B.

Results: Manipulatives - Mathematics

Table 1 shows the percentage of the respondents selecting each choice for each of the eight questions for grades K-2 and 3-5. Several statistics in the table are worthy of special note. Questions 1 and 2 dealt with the availability of manipulatives in the classroom. In grades K-2, 40% of the respondents indicated almost all teachers had commercially-made manipulatives available to them (question 1) and 42% indicated almost all teachers had teacher-made manipulatives available to them (question 2). Very few respondents (3% on question 1 and 7% on question 2) indicated no teachers had manipulatives available to them. Fifty-eight percent of teachers in grades K-2 use manipulatives 42 or more days per year while only 33% of teachers in grade 3-5 use manipulatives this often (question 3). The high percentages on response options 3 and 4 for questions 4 and 5 indicate that manipulatives are used both to help students learn computational skills and to understand broad concepts. Frequent middle range responses to question 6 indicate that manipulative use was of moderate concern in the selection of mathematics textbooks. Responses to questions 7 and 8 indicate that almost all teachers use some combination of hands-on and non-hands-on instruction as only 2 to 3 percent of the respondents selected choice 1 (none) for these items.

Table 2 gives means, standard deviations and *t*-test results for statistically significant differences between responses for grades K-2 and 3-5. Note that responses of "0" (unable to answer) were not included in the statistics for questions 3 through 6 of Table 2 and thus the sample size for these items is somewhat smaller than for items 1 and 2. All comparisons shown in Table 2 were statistically significant at the $p<.01$ level.

Table 1

Response Percentages for Each Question for Grades K-2 and Grades 3-5 (N=301)

Question	Grades K-2						Grades 3-5					
	0	1	2	3	4	5	0	1	2	3	4	5
1. Teachers having commercially-available manipulatives[a]		7	21	15	17	40		17	24	17	16	26
2. Teachers having teacher-made manipulatives[a]		3	12	20	23	42		9	22	27	19	23
3. Days per year pupils use manipulatives[b]		5	11	26	29	29		8	25	34	23	10
4. Use of manipulatives to "learn the rules"[c]	4	1	9	31	44	11	4	1	14	42	34	5
5. Use of manipulatives to understand concepts[c]	3	3	16	31	37	10	2	1	19	42	28	8
6. Extent to which manipulatives were considered in textbook selection[d]	6	5	22	29	30	8	5	7	22	32	28	6
7. Time per week spent on "hands-on" teaching[e]		2	44	37	15	2		3	66	22	8	1
8. Time per week spent on "non-hands-on" teaching[e]		2	17	31	44	6		2	10	19	56	13

[a] 1 = less than 10% 2 = 10% to 39% 3 = 40% to 60%
4 = 61% to 89% 5 = 90% to 100%

[b] 1 = less than 10 2 = 10 to 21 3 = 22 to 41
4 = 42 to 89 5 = 90 or more

[c] 1 = not used at all 2 = once in a great while 3 = not often
4 = often, not always 5 = most or all of the time

[d] 1 = was not a factor 2 = considered occasionally 3 = considered often
4 = considered extensively 5 = was the main factor

[e] 1 = none 2 = 1-59 minutes 3 = 60-119 minutes
4 = 120-240 minutes 5 = more than 240 minutes

Table 2

Means, Standard Deviations, and t-Test Results Comparing Manipulative Use in Grades K-2 to Grades 3-5

Question	N	Grades K-2 M	Grades K-2 SD	Grades 3-5 M	Grades 3-5 SD	t
1. Teachers having commercially-available manipulatives[a]	29	3.62	1.37	3.11	1.47	9.01**
2. Teachers having teacher-made manipulatives[a]	290	3.90	1.16	3.27	1.28	11.83**
3. Days per year pupils use manipulatives[b]	289	3.66	1.15	3.04	1.11	11.32**
4. Use of manipulatives to "learn the rules"[c]	277	3.58	.85	3.31	.83	6.38**
5. Use of manipulatives to understand concepts[c]	283	3.37	.98	3.24	.89	3.18*
6. Extent to which manipulatives were considered in textbook selection[d]	274	3.15	1.03	3.05	1.03	2.80*
7. Time per week spent on "hands-on" teaching[e]	287	2.69	.82	2.37	.74	7.98**
8. Time per week spent on "non-hands-on"teaching[e]	287	3.33	.91	3.67	.88	-8.98**

[a]1 = less than 10%; 2 = 10% to 39%; 3 = 40% to 60%; 4 = 61% to 89%; 5 = 90% to 100%

[b]1 = less than 10; 2 = 10 to 21; 3 = 22 to 41; 4 = 42 to 89; 5 = 90 or more

[c]1 = not used at all; 2 = once in a great while; 3 = not often; 4 = often, not always; 5 = most or all of the time

[d]1 = was not a factor; 2 = considered occasionally; 3 = considered often; 4 = considered extensively; 5 = was the main factor

[e]1 = none; 2 = 1-59 minutes; 3 = 60-119 minutes; 4 = 120-240 minutes; 5 = more than 240 minutes

*$p<.01$; **$p<.001$

As can be seen in Table 2, teachers in grades K-2 had commercially-available and teacher-made manipulatives available for use more often than teachers in grades 3-5 (questions 1 and 2). K-2 teachers also used the materials available to them more days during the school year than did teachers in grades 3-5 (question 3). Manipulatives were used to learn rules more in grades K-2 than in grades 3-5 (question 4). They were also used to develop broad concepts more in grades K-2 than in grades 3-5 (question 5). Manipulatives were more important factors in textbook selection in grades K-2 than in grades 3-5 (question 6). More class time was spent with hands-on teaching in grades K-2 than in grades 3-5 (question 7) and more time was spent with non-hands-on teaching in grades 3-5 than in grades K-2 (question 8).

In addition to differences between grades K-2 and 3-5, *t*-tests comparing responses across several of the items were of interest. Table 3 reports those results. The first comparisons reported in Table 3 were to determine whether teacher-made manipulatives were more readily available than more expensive commercially-available manipulatives. As can be seen from the first comparison reported in Table 3, teacher-made manipulatives were available significantly more often than commercially-available manipulatives in grades K-2. This comparison was not, however, statistically significant for grades 3-5 (comparison 2). Comparisons 3 and 4 in Table 3 indicate that manipulatives were used more frequently for learning rules and computations than for understanding broad concepts in both grades K-2 and 3-5. This comparison was statistically significant, however, only in grades K-2. The last two comparisons reported in Table 3 indicate that more time is spent teaching mathematics through non-hands-on rather than hands-on techniques.

Table 3

Means, Standard Deviations, and t-Tests Comparing Aspects of Manipulative Use

Questions Being Compared	N	Question A M	Question A SD	Question B M	Question B SD	t
1. Question 1 vs. Question 2, grades K-2	295	3.62	1.38	3.91	1.16	-4.53**
2. Question 1 vs. Question 2, grades 3-5	294	3.11	1.47	3.26	1.28	-2.02
3. Question 4 vs. Question 5, grades K-2	279	3.56	0.85	3.37	0.97	3.08*
4. Question 4 vs. Question 5, grades 3-5	281	3.30	0.83	3.25	0.88	1.27
5. Question 7 vs. Question 8, grades K-2	292	2.70	0.82	3.33	0.91	-8.57**
6. Question 7 vs. Question 8, grades 3-5	291	2.37	0.73	3.68	0.89	-18.55**

*$p<.01$; **$p<.001$

These comparisons were statistically significant for both grade level categories surveyed although the difference in the means of the two groups was considerably greater for grades 3-5.

Discussion: Manipulatives - Mathematics

Availability of mathematical manipulatives for teachers was the first major question addressed in this study. Eighty-five percent of the respondents indicated that at least 40% of the K-2 teachers in their schools had teacher-made manipulatives available to them (Question 1, Table 1). The corresponding statistic for grades 3-5 was 79% (Question 1, Table 1). Commercially-available manipulatives were provided significantly less often in grades K-2 but about the same amount in grades 3-5 (Comparisons 1 and 2, Table 3). Comments provided on some of the questionnaires indicated more concern about materials availability than was apparent from responses to specific questions. For example, one respondent noted "Hands-on materials (commercial) are beyond the budget of our elementary schools" and another said "Several teachers have indicated that they would love to use more manipulatives and models if the funding were available for the purchase of them or the materials to make them". In short, the data reported in Table 1 indicate that a majority of teachers have some sort of manipulatives available to them. Many of the written comments, however, were in agreement with a finding reported by Fey (1979) that the most serious problem in teaching mathematics mentioned by elementary school teachers was insufficient funds for purchasing equipment and supplies. It is possible that this discrepancy is due to the fact that while teachers have some materials available to them, additional quantities and types of manipulatives would be useful.

Results from questions 3 and 4 (Table 1) of the survey instrument indicate that manipulatives are used both to help students learn facts and rules and to develop broad mathematical ideas. While manipulatives are intended to promote understanding more than they are intended to aid memorization (Driscoll, 1980), increased understanding often makes memorization easier and thus manipulatives can be thought of as aids to learning rules. The fact that manipulatives were used to learn rules significantly more than to understand concepts only in grades K-2 (Table 3, Comparisons 3 and 4) is probably attributable to the commonly held belief that skill development should be the foremost goal of the primary grades (Fey, 1979).

On the question of manipulative (hands-on) as compared to non-manipulative (non-hands-on) mathematics teaching, results tend to revalidate findings reported by Fey (1979) that non-manipulative instruction is more prevalent. Some teachers do have and use manipulatives. Fifty-eight percent of primary grade (K-2) and 33% of intermediate grade (3-5) teachers were reported as using manipulatives at least 42 days per school year (Question 3, Table 1), or more than once a week. Non-manipulative instruction, however, is predominant. In grades K-2, manipulatives were used at least 60 minutes per week 54% of the time (Question 7, Table 1) while non-manipulative instruction took place at least 60 minutes per week 81% of the time (Question 7, Table 1). This difference was statistically significant (Comparison 5, Table 3). A comment on manipulative use offered by one respondent was that "This is not the way we were taught to teach! . . . Money for textbooks we have - manipulatives are 'frills' and viewed by most as 'playtime'".

Substantiating a statement made by Suydam (1984), manipulatives are used much less often in the intermediate grades than in the primary grades (Comparison 3, Table 2). The magnitude of this difference is apparent from responses to questions 7 and 8 shown in Table 1. Manipulative activities took place at least 60 minutes per week in 31% of the classrooms while non-manipulative activities took place at least 60 minutes per week in 88% of the classrooms.

In summary, the data reported here indicate that manipulative activities are a part of mathematics instruction in many but certainly not all elementary school classrooms. An important unanswered question is the extent to which manipulatives are being used to help children build conceptual models of mathematical ideas. Such questions cannot be determined from a large-scale survey of this type. It is apparent from this study that non-manipulative mathematics instruction is still the norm in the area where data were collected, particularly in the upper elementary grades. The extent to which teachers and principals see a need to improve instruction through appropriate introduction of manipulatives is unclear, although comments provided on some of the questionnaires provide cause for optimism. One respondent wrote "Teachers are . . . 'book' oriented. We need to use hands-on materials much more than we do;" while another stated "We have adopted a math curriculum that has good directions for using manipulatives".

Results: Problem Solving - Mathematics

Table 4 shows the percentage of the respondents selecting each choice for each of the four questions for grades K-2 and 3-5. As can be seen in Table 4, respondents indicated moderate orientation toward problem solving in grades K-2 as 47% of the time response option 3 (sometimes) was chosen and 25% of the time response option 4 (fairly often) was chosen. There was somewhat more of a problem-solving orientation in grades 3-5 as response option 3 was selected 34% of the time while response option 4 was chosen 47% of the time. The increased importance of problem solving in the higher grades was found to be statistically significant as shown by the t-test reported for question 1 in Table 5. Note that all *t*-tests reported in Table 5 were statistically significant well beyond the $p<.01$ level chosen for this study.

The second question addressed was that of the number of minutes per week spent on activities designed to foster higher-level thinking skills. In the primary grades, time spent per week was reported to be 1 to 59 minutes (response option 2) 52% of the time and 60 to 119 minutes (response option 3) 31% of the time (Table 4). For grades 3-5, more time was spent developing higher-level thinking skills as 45% of the respondents chose 60 to 119 minutes and an additional 20% chose 120 to 240 minutes (Table 4). The *t*-test for question 2 (Table 5) indicated that significantly more time was spent fostering higher-level skills in grades 3-5 than in grades K-2.

The third question addressed commitment to teaching problem solving by assessing the frequency with which non-text problem-solving activities were used in classrooms. The response chosen 41% of the time for grades K-2 was one to three times per month (response option 2). Four to six times per month

Table 4

Response Percentages for Each Question for Grades K-2 and Grades 3-5 (N=317)

Question	Grades K-2 0	1	2	3	4	5	Grades 3-5 0	1	2	3	4	5
1. Curriculum geared toward problem solving and understanding of broad concepts[a]		3	18	47	25	7		0	6	34	47	13
2. Weekly time spent fostering "higher level" thinking skills[b]	2	3	52	30	10	3	2	1	27	45	20	5
3. Times per month activities not found in textbooks are brought in to promote problem solving and "higher level" thinking skills[c]	2	13	41	26	11	7	1	10	31	35	15	8
4. Importance of problem solving and promoting the development of thinking skills in textbook selection[d]	5	3	23	36	28	5	4	2	15	36	36	7

[a] 1 = practically never 2 = once in a great while 3 = sometimes
4 = fairly often 5 = very often

[b] 1 = none 2 = 1 to 59 minutes 3 = 60 to 119 minutes
4 = 120 to 240 minutes 5 = more than 240 minutes

[c] 1 = almost never 2 = 1 to 3 times/month 3 = 4 to 6 times/month
4 = 7 to 9 times/month 5 = 10 or more times/month

[d] 1 = were not factors 2 = considered occasionally 3 = considered often
4 = considered extensively 5 = were the main factors

Table 5

Means, Standard Deviations, and t-Test Results Comparing Problem Solving Orientation in Grades K-2 to Grades 3-5

Question	N	Grades K-2 M	Grades K-2 SD	Grades 3-5 M	Grades 3-5 SD	t
1. Curriculum geared toward problem solving and understanding of broad concepts[a]	306	3.15	0.88	3.66	0.80	-11.23**
2. Weekly time spent fostering "higher level" thinking skills[b]	300	2.55	0.82	3.04	0.86	-11.56**
3. Times per month activities not found in textbooks are brought in to promote problem solving and "higher level" thinking skills[c]	300	2.57	1.10	2.81	1.08	- 5.20**
4. Importance of problem solving and promoting the development of thinking skills in textbook selection[d]	290	3.09	0.92	3.32	0.90	- 6.99**

[a]1 = practically never 2 = once in a great while 3 = sometimes
4 = fairly often 5 = very often

[b]1 = none 2 = 1 to 59 minutes 3 = 60 to 119 minutes
4 = 120 to 240 minutes 5 = more than 240 minutes

[c]1 = almost never 2 = 1 to 3 times/month 3 = 4 to 6 times/month
4 = 7 to 9 times/month 5 = 10 or more times/month

[d]1 = were not factors 2 = considered occasionally 3 = considered often
4 = considered extensively 5 = were the main factors

*$p<.01$, **$p<.001$

(response option 3) was selected 26% of the time and seven to nine times per month was selected 11% of the time (Table 4). For grades 3-5, one to three times per month was chosen 31% of the time, four to six times per month was chosen 35% of the time, and seven to nine times per month was chosen 14% of the time (Table 4). As shown in Table 5, the frequency with which non-text problem-solving activities were used was significantly greater for grades 3-5 than for grades K-2.

The final survey question dealt with the extent to which problem solving had been a factor in textbook selection. As with the other questions, problem-solving and critical-thinking skills were issues of moderate importance in text selection. In grades K-2, problem solving and thinking skills were "considered occasionally" (response option 2) 23% of the time, "considered often" (response option 3) 36% of the time and "considered extensively" (response option 4) 28% of the time. In grades 3-5, problem solving and thinking skills were considered occasionally 15% of the time, considered often 36% of the time, and considered extensively 36% of the time. The difference in importance of problem solving and critical thinking between grades K-2 and 3-5 was statistically significant with these skills being of higher importance in grades 3-5 (Table 5).

Discussion: Problem Solving - Mathematics

The data presented indicate that in general, problem solving is an issue of varying importance in elementary schools. The high response rate to the survey make the findings resonably generalizable across the midwest and probably other regions as well. The fact that most responses to all of the questions were in the middle categories (response options 2, 3 and 4, Table 4) implies that problem solving and critical thinking are of moderate importance in the high majority of schools. The very small percentages of responses marked "unable to answer" (Table 4) show that individuals completing the survey felt they knew enough about problem solving instruction in their schools to answer questions about it. The statistically significant t-tests shown in Table 5 make it clear that problem solving and critical thinking are viewed as being more important in the upper elementary grades (3-5) than in the primary grades (K-2). The fact that problem solving was viewed as at least somewhat important in the primary grades may be a belief, such as that expressed by Bruni (1982) and Wheatley and Wheatley (1984) that problem solving is an appropriate topic for primary-grade children. Modest acceptance of problem solving as a focus in the primary grades could also be a reflection that new mathematics textbooks include problem solving at all grade levels.

A limiting factor in the validity of the data reported here is that the questionnaires were sent to and predominantly completed by elementary school principals. However, the fact that questionnaires completed by classroom teachers contained responses that were not significantly different from those of the principals is an indication that the principals did know enough about the teachers in their schools to accurately respond to the instrument.

A final factor to consider when looking at these results is that they are indicative of the "average" teacher in a school. Undoubtedly, there are teachers who are doing an outstanding job of teaching problem solving and critical thinking to their students. As one principal commented, "I regret these answers! We have a few teachers of our 48 who certainly score much higher, but the norm is indicated."

In summary, it is safe to say that problem solving is of moderate importance in a majority of elementary schools. In addition, problem solving is of high importance in a few schools and of almost no importance in a few others. As a general rule, problem solving is of greater importance in the upper as opposed to the lower elementary grades. Progress is being made in improving problem-solving instruction. As one respondent stated, "I believe very much in the ideas mentioned. I believe teachers can be convinced (without muc' trouble) to begin these type of activities." In short, effective problem-solving instruction in mathematics is a goal that some schools, but certainly not all, are beginning to meet.

Results: Computers - Mathematics

Table 6 shows the percentage of the respondents selecting each choice for each of the four questions for grades K-2 and 3-5. As can be seen in Table 6, 66% of the respondents indicated students in grades K-2 used computers 1 to 30 minude the concrete experiences students need to gain initial understanding of concepts. Herbert (1985) spoke of the motivational advantages of using manipulatives to teach mathematics. The introduction of calculators and computers into our society, has, if 1 to 30 minutes per week to practice previously learned materials while 34% indicated students used computers for drill and practice 31 to 60 minutes per week (Table 6). Only 11% of students in grades K-2 and 5% of students in grades 3-5 were reported as not using computers at all (response option 1) for practicing previously learned materials. Table 7 shows comparisons between computer use in grades K-2 and 3-5 for each of the four categories of computer use considered. As can be

Table 6

Response Percentages for Each Question for Grades K-2 and Grades 3-5 (N=317)

Weekly time spent using computer to:	Grades K-2					Grades 3-5				
	1	2	3	4	5	1	2	3	4	5
1. Practice previously learned material	11	66	20	2	1	5	54	34	6	1
2. Learn new material	35	56	8	1	0	29	55	13	2	1
3. Learn by computer simulation	46	47	5	1	1	26	55	14	4	1
4. Develop problem-solving and/or "higher-level" thinking skills	42	50	6	2	0	21	58	15	5	1

Note: 1 = not at all 2 = 1 to 30 minutes 3 = 31 to 60 minutes
4 = 61 to 120 minutes 5 = more than 120 minutes

Table 7

Means, Standard Deviations, and t-Test Results Comparing Computer Utilization in Grades K-2 to Grades 3-5 (N=317)

Weekly time spent using computer to:	Grades K-2		Grades 3-5		
	M	SD	M	SD	t
1. Practice previously learned material	2.15	.68	2.45	.73	- 7.59**
2. Learn new material	1.76	.66	1.92	.76	- 4.89**
3. Learn by computer simulation	1.64	.70	2.00	.80	- 9.63**
4. Develop problem-solving and/or "higher-level" thinking skills	1.68	.69	2.07	.77	-10.43**

Note: 1 = not at all 2 = 1 to 30 minutes 3 = 31 to 60 minutes 4 = 61 to 120 minutes 5 = more than 120 minutes

*$p<.01$, **$p<.001$

seen from the first comparison in Table 7, computers were used to practice previously learned material more often in grades 3-5 than in grades K-2. Note that all t-tests reported in Table 7 were statistically significant well beyond the $p<.01$ level chosen for this study.

The second question asked of respondents was the extent to which computers were used to learn new material. In other words, they were asked to indicate the extent to which tutorial programs were used to teach mathematics. As can be seen from Table 6, 35% of students in grades K-2 did not use mathematics tutorials while an additional 56% used them no more than 30 minutes per week. In grades 3-5, 29% of students did not use mathematics tutorials and 55% used them 30 minutes per week or less (Table 6). While students did not often use computers to learn new material in either of the grade level categories surveyed, they used them significantly more often in grades 3-5 than in grades K-2 (Table 7).

The third item on the questionnaire dealt with teaching mathematics by way of a computer simulation. In grades K-2, 46% of the pupils were reported as not using computers for simulations and and additional 47% were reported as using computers for simulations 30 minutes per week or less (Table 6). In grades 3-5, 26% of pupils were not using simulations while 55% were using simulations up to 30 minutes per week and 14 percent were using simulations 31 to 60 minutes per week (Table 6). Computer simulations were used to help students learn mathematics significantly more often in grades 3-5 than in grades K-2 (Table 7).

The final question required an estimate of the extent to which pupils were using computers to develop problem-solving and higher-level thinking skills. As was the case with tutorial and simulation applications of the computer, problem-solving applications were used infrequently. In grades K-2, 42% of students did not use a computer for problem solving while 50% used a computer for problem solving 1 to 30 minutes per week (Table 6). In grades 3-5, 21% of students did not use the computer for problem solving, 58% used a computer for problem solving 1 to 30 minutes per week, and 15% used a computer for problem solving 31 to 60 minutes per week (Table 6). Paralleling findings for questions 2 and 3, problem-solving applications of the computer were more prevalent in grades 3-5 than in grades K-2 (Table 7).

Discussion: Computers - Mathematics

The high return rate on the questionnaire (76%) indicates the results reported here are generalizable throughout and possibly beyond the State where data were collected. In general, the findings of this study agree with findings from other recent studies of computer usage in elementary schools. Drill and practice was the most frequent type of computer utilization as suggested by Elron (1983) and Long (1985). Paralleling findings of Dickey and Kherlopian (1987), tutorial, simulation, and problem-solving software were used in some classrooms but not used in many others. Software quality, often thought to be a barrier to computer utilization, was rarely noted as a problem in the comments section of the questionnaire. This result matches that of Becker (1986) who reported that poor quality software was not nearly the problem that lack of equipment was in the schools he studied.

Studies comparing primary to intermediate grade use of computers were not found in the literature review. The current finding of significantly greater computer use at the intermediate level, however, is believable as students in the upper elementary grades are better readers and thus more able to use CAI software without extensive assistance.

One factor that needs to be remembered in interpreting the findings of this study is that the data are indicative of the "average" pupil in a school. As computer utilization within an elementary school commonly varies considerably by teacher (Kloosterman et al., 1987), it is probable that some students are using computers to learn mathematics quite frequently while others are probably using computers infrequently if at all.

In summary, it is safe to say that computers are currently available in most elementary schools. Rather than just programming, they are being used to teach and practice academic subject matter which was formerly presented through lecture or printed material. Simulation and problem-solving software force students into critical thinking about topics not frequently addressed before computers were available. Computers are used for mathematics instruction more frequently in intermediate than in primary grades but they are used, at least for drill and practice, in a substantial majority of primary classrooms. In short, the goal of taking full advantage of computers for mathematics instruction has yet to be attained but progress is being made at a faster pace than may have originally been expected.

Results: Manipulatives - Science

The results of the statewide survey are broken down and analyzed according to the: (1) quantity of manipulatives, (2) use of manipulatives, (3) implications of manipulatives, and (4) manipulatives and textbooks. The findings are discussed by way of mean responses, standard deviations, and percentage of response per rating category. Also, tests of significance between grades K-2 (lower level) and grades 3-5 (upper level) responses are discussed.

Quantity of Manipulatives:

When considering the amount of commercial hands-on materials available (Table 8), it was found that upper elementary school classrooms (K-2) have significantly more (M= 3.4, SD=1.3) manipulatives than lower elementary classrooms (M=3.1, SD=1.5). A t-value of 7.1 was found to be significant at the 0.001 level. In grades K through 2, the distribution of responses was fairly uniform as 42% of the respondents indicated less than 40% of their teachers had commercially-made manipulatives available and 41% indicated more than 60% of their teachers had commercially-made manipulatives available. In grades 3 through 5, responses were skewed more toward teachers having commercially-made manipulatives as 55% of the respondents indicated 60% or more of their teachers had commercially-made manipulatives available for use.

Teacher-made manipulatives for science teaching were available somewhat more often than commercially-produced materials (Table 8). Upper elementary school teachers (M=3.5, SD=1.2) have significantly more ($t=3.3$, $p<0.001$) teacher-made manipulatives than lower elementary school teachers (M=3.4, SD=1.3). Only one-fourth of the respondents, however, reported that all of the teachers in their schools possessed teacher-made manipulatives for the teaching of science.

TABLE 8

SCIENCE HANDS-ON TEACHING-LEARNING UTILIZATION

Dimensions \ Perceptions	Grades K-2		Grades 3-5		t-value	p
	M	SD	M	SD		
Percent of Teacher Having Commercially-Available "Hands-On" Manipulatives in the Classroom	3.1	1.5	3.4	1.3	7.1	0.001
Percent of Teachers Having Teacher-Assembled "Hands-On" Manipulatives Accessible	3.4	1.3	3.5	1.2	3.3	0.001
Days/Year Pupils Use "Hands-On" Manipulatives	2.9	1.1	3.1	1.0	3.5	0.001
Application of "Hands-On" Experience toward "Learning the Rules" Rather than Understanding the Concepts	2.9	0.9	3.1	0.9	3.3	0.001
Application of "Hands-On" Experience toward Understanding Concepts or Solving Problems Creatively	3.2	1.0	3.3	1.0	3.7	0.001
Extent to Which "Hands-On" Models Considered in Most Recent Textbook Selection	3.2	1.0	3.3	1.0	3.7	0.001
Time/Week Spent on "Hands-On" Teaching	2.3	0.7	2.5	0.8	4.5	0.001
Time/Week Spent on Non-Hands-On" Teaching	2.9	0.9	3.3	0.8	7.9	0.001

Use of Manipulatives:

The use of manipulatives during science teaching aspect of the instrument included questions on: (1) days per year pupils use hands-on manipulatives, (2) time per week spent on hands-on teaching, and (3) time per week spent on non-hands-on teaching (Table 8). The number of days per school year that pupils use hands-on materials, manipulatives, or physical models (either commercial or teacher-made), in upper elementary classrooms ($M=3.1$, $SD=1.0$) was significantly greater ($t=3.5$, $p<0.001$) than the number of days that lower grade level classes used such materials ($M=2.9$, $SD=1.1$). Approximately 30% of all elementary classrooms employed hands-on materials for 22 to 41 days per year; only 8% of all classrooms utilized manipulatives 90 or more days. Ten percent of the classrooms at the lower grade levels and 6% at the upper level employed hands-on materials less than 10 days during a given school year.

An additional question on the survey addressed the issue of the average minutes per week (Table 8) devoted to the hands-on teaching of science. Classrooms at the upper elementary school level ($M=2.5$, $SD=0.8$) used manipulatives significantly more ($t=4.5$, $p<0.001$) minutes per week than lower elementary school classrooms ($M=2.3$, $SD=0.7$). Respondents indicated that approximately 70% of the lower grade level and 60% of the upper grade level classrooms used hands-on materials but used them less than 60 minutes per week. Less than 2% of all elementary classrooms employ an inquiry approach for more than 240 minutes per week.

As shown in Table 8, the number of minutes per week that students experienced non-manipulative science teaching was somewhat greater than the number of minutes of hands-on construction. In most cases non-manipulative instruction consisted of reading about science in a textbook series.

Classrooms at the upper elementary school level ($M=3.3$, $SD=0.8$) experienced significantly more ($t=7.9$, $p<0.001$) non-hands-on science time than lower level classrooms ($M=2.9$, $SD=0.9$). Approximately 40% of all elementary classrooms engaged in non-manipulative science activities for 60 to 120 minutes per week. Respondents also indicated that 27% of the lower and 44% of the upper elementary school classrooms experience more than 120 minutes per week of non-inquiry-oriented science. Sadly enough, 3% of the lower and 2% of the upper level classrooms had no science at all. These data reflect additional sad tones when considering less than an hour of science per week was taught in 30% of the lower and 15% of the upper elementary school classrooms reported.

Applications of Hands-On Instruction:

Two basic areas (Table 8) where there are direct implications from the use of manipulatives are: (1) to facilitate the understanding of concepts, and (2) to enhance the problem solving process. With respect to the first area, information was sought concerning the extent to which manipulatives are used to help pupils "learn the rules" for measuring, estimating, etc. rather than understand how or why these rules work. Specifically, during science activities hands-on materials might be used to learn the rules for graphing, operationally defining, variable identification, classification, etc. Classrooms at the upper elementary school level ($M=3.1$, $SD=0.9$) employed manipulatives significantly more ($t=3.3$, $p<0.001$) to learn rules than classrooms at the lower elementary level ($M=2.9$, $SD=0.9$). Six percent (6%) of the respondents did not feel they could respond to this dimension and 4% said their teachers never employed hands-on materials for the purpose of learning rules. Surprisedly, 4% of the schools utilized manipulatives only for learning rules.

The use of manipulatives to enhance the problem solving process (Table 8) might specifically include situations where materials are used for explaining inductive and deductive approaches, setting up controlled experiments, doing science fair projects, etc. Classrooms at the upper elementary school level (M=3.3, SD=1.0) had experienced significantly more (t=3.7, p<0.001) activities where manipulatives were used to promote problem solving than classrooms at the lower grade levels (M=3.2, SD=1.0). Roughly 4% of all elementary schools were not in a position to respond to the concern, and an additional 3% had never used manipulatives for this purpose. On the positive side approximately 6% of all elementary classrooms employed hands-on materials to enhance problem solving ability most, if not all, of the time.

Manipulatives and Textbooks:

An additional dimension of the study (Table 8) focused on the amount of influence hands-on materials, manipulatives or physical models had on textbook selection. Classrooms at the upper elementary school level (M=3.3, SD=1.0) possessed textbooks which were significantly influenced more (t=3.7, p<0.001) by the incorporation of activities involving hands-on experience than classrooms at the lower grade levels (M=3.2, SD=1.0). Some 7% of the respondents were unable to determine whether this was a consideration in their text selection. Also, on a negative note, an additional 4% of the schools reported that manipulative usage was not a factor considered during the selection process. On the brighter side approximately 9% of the schools noted that the incorporation and promotion of manipulatives was the main factor in selecting a textbook.

Conclusions

When taking into account all of the concerns about manipulatives or hands-on materials considered in this study, the percent of teachers having teacher-assembled hands-on manipulatives accessible was rated the highest for both the lower grades (K-2) and the upper grades (3-5). About 50% to 60% of elementary school teachers have these materials to use. Also, contrary to popular opinion, most elementary schools report teaching science in some capacity. Grade level differences in use of manipulatives and hands-on materials were apparent on all study dimensions. Upper grade level teachers used materials and taught science significantly more than lower grade level teachers.

Comments provided on some of the returned instruments reflected more concern about hands-on materials availability than was apparent from responses to specific questions. For example, one respondent noted that commercial hands-on materials are beyond the budgets of elementary schools, and another reported that several teachers have indicated that they would like to use more manipulatives and models if the funding were available for the purchase of them or the materials to make them.

In addition, the data reported here indicate that manipulative activities are being used to help pupils build conceptual models of science ideas. A response to such concerns cannot be determined from a large-scale survey of this type. It seems apparent from this study that non-manipulative science instruction is still the norm in the area where data were collected. The extent to which teachers and principals see a need to improve instruction through an appropriate introduction of manipulatives is unclear, although comments provided on some of the instruments provide cause for optimism. One respondent noted that teachers are . . . "book" oriented and need to use hands-on materials much more than they do.

Based on the above findings and suggested inferences, the following conclusions have been drawn:

- On the average about half of the teachers have hands-on manipulatives available in their classrooms. The percentage of classrooms with commercially available science manipulatives is a little higher than the percentage of classrooms with teacher-assembled science manipulatives. In addition, teachers in the upper elementary grades have more science manipulatives than lower grade level teachers. There is also considerable variation from school to school in terms of the findings.

- On the average, teachers use hands-on science materials about 30 days a year; however, this figure varies considerably from school to school.

- Hands-on science materials are used to help students both "learn the rules" for a procedure and to understand broad concepts. The materials are used for these purposes a little more in the upper grades than in the lower grades.

- On the average, lower grade level teachers spend about 70 minutes per week teaching science with manipulatives and 90 minutes per week teaching science without manipulatives. For teachers at the upper grade levels, these amounts are slightly higher. Anecdotal data reflect that these figures may be too high.

Results: Problem Solving - Science

The dimensions investigated were: (1) curriculum orientation toward problem solving and understanding broad concepts, (2) weekly amount of time engaged in promoting higher-level thinking skills among pupils, (3) quantity of time spent monthly engaged in non-textbook problem solving activities, and (4) the importance of problem solving and thinking skills development in the most recent textbook selection. The findings and commentary have been geared toward a comparison of the lower elementary school grades (K thru 2) and the upper elementary school grades (3 thru 5). Percentages, mean scores, and standard deviations also have utilized to make descriptive quantitative comparisons.

Curriculum Orientation:

The focus of this dimension was on the extent to which the science program is geared toward problem solving and understanding of broad concepts as opposed to following the rules to get an answer to a science question. Activities might lead to understanding cohension, a cell, sound, controlling variables, etc. The science curriculum (Table 9) at the upper elementary school level ($M=3.7$, $SD=0.9$) was found to have a significantly greater ($t=12.3$, $p<0.001$) emphasis on problem solving and broad concept development than the science program at lower grade levels ($M=3.0$, $SD=0.9$). Less than one percent of the schools revealed that they never employed these strategies (0.6% for lower grades and 0.3% for upper grades). On a really positive note 58% of the schools indicated that upper grade level teachers utilize these approaches fairly often to very often. At the lower grade levels 64% of the schools noted that teachers emphasize problem solving and broad concept understanding once in a great while to sometimes.

Amount of Problem Solving:

This dimension possessed two areas of investigation. The first concern involved an approximate number of minutes per week pupils spend on activities designed to foster "higher level" thinking skills. During science activities pupils might apply science concepts to new situations, learn about inductive and deductive approaches, create controlled experiments, etc. Classrooms (Table 9) at the upper elementary school grade levels ($M=2.7$, $SD=0.9$) spent significantly more ($t=12.8$, $p<0.001$) time per week nurturing higher-level thinking skills than their counterparts at the lower grade levels ($M=2.2$, $SD=0.7$). At the lower level grade levels 80% of the reporting elementary schools revealed that 1 to 119 minutes (0 to 2 hours) were utilized in activities which promoted higher order skills' development. At the upper elementary school grades roughly 16% of the classrooms experienced 120 to more than 240 minutes (2 to more than 4 hours) per week.

The second concern focused on the frequency with which teachers bring in activites beyond those found in the textbook that promote problem solving and the development of higher-order thinking skills. The science programs

TABLE 9

SCIENCE CLASSROOM PROBLEM SOLVING APPROACHES

Dimensions \ Reactions	Grades K-2		Grades 3-5		t-value	p
	M	SD	M	SD		
Curriculum Geared toward Problem Solving and Understanding of Broad Concepts	3.0	0.9	3.7	0.9	12.3	0.001
Weekly Time Spent toward Fostering "Higher Level" Thinking Skills	2.2	0.7	2.7	0.9	12.8	0.001
Times per Month Activities Not Found in Textbooks Are Brought in to Promote Problem Solving and "Higher Level" Thinking Skills	2.5	1.0	2.9	1.1	7.9	0.001
Importance of Problem Solving and Promoting the Development of Thinking Skills in Most Recent Textbook Selection	2.8	0.9	3.0	0.9	7.9	0.001

(Table 9) at the upper grade levels (M=2.9, SD=1.1) experienced significantly more (t=7.9, p<0.001) nontextbook problem solving and higher order skills' development activities than the organized science curricula at the lower grade levels (M=2.5, SD=1.0). At the lower grade levels 70% of the elementary schools indicated that nontextbook activities were implemented one to six times per month. At the upper elementary school grades 50% of the classrooms experienced beyond-the-textbook approaches for promotion problem solving and higer-order skills development four to nine times per month.

Problem Solving/Higher-Order Thinking Priorities:

The emphasis of this dimension focused on how much a factor the teaching of problem solving and promoting the development of thinking skills were in the most recent (or current) textbook selection process. Textbook selection (Table 9) at the upper elementary grade levels (M=3.0, SD=0.9) was influenced significantly more (t=7.9, p<0.001) by these factors than were textbooks selected at the lower grade levels (M=2.8, SD=0.9). These factors were considered occasionally or often at the lower elementary school grade levels by 61% of the reported elementary schools. At the upper grade levels 60% of the elementary schools reported that these factors were considered often or extensively in the textbook selection process.

Discussion

When considering the four dimensions associated with problem solving and high-order thinking skills development, the concern of the weekly amount of time spent in promoting problem solving/higher-order thinking skills was rated the lowest at both the lower grade and the upper grade levels. The aspect rated the highest for both the lower and upper grade level was associated with the science curriculum orientation toward problem solving and understanding of broad concepts. Significant differences were found between the lower and upper grade levels on all four dimensions. The concern exhibiting the greatest disparity between the grade levels was the weekly amount of time engaged in promoting higher-order thinking skills among pupils. The least amount of discrepancy between the levels was associated with the concerns of quantity of time spent monthly engaged in non-textbook problem solving activities and the importance of problem solving and thinking skills development in the most recent textbook selection.

Basically, the only conclusion to be generated is that the implementation of activities that promote problem solving ability, higher-order skills development, and the understanding of broad concepts in science are goals of moderate importance. They are somewhat more important at the upper elementary school grade levels (3 thru 5) than they are at the lower grade levels (K thru 2).

A final critical factor to consider is that results reported here are indicative of the "average" teacher in an elementary school. Undoubtedly, there are teachers who are doing an outstanding job of teaching problem solving and critical thinking to their pupils. One principal noted that there are a few teachers who certainly score much higher, but the norm was indicated.

In summary, it is safe to assume that problem solving is of moderate importance in a majority of the elementary schools. In addition, problem solving is of high importance in a few schools and of almost no importance in a few others. As a general rule, problem solving is of greater importance in the upper as opposed to the lower elementary grades. Progress is being made with respect to enhancing problem-solving instruction. One respondent reported that teachers can be convinced (without much trouble) to begin these type of activities. In short, progress is being made toward the goal of effective problem-solving science instruction, but there is still room for improvement.

Results: Computers - Science

The dimensions examined included the number of minutes per week that an average pupil used the microcomputer, either alone or in a small group to: (1) practice previously learned materials, (2) learn new information or subject matter, (3) learn by way of a computer simulation, or (4) attempt to develop problem solving and/or higher-order thinking skills. These concerns will be analyzed by way of the lower (grades K-2) and upper (grades 3-5) grade levels. Quantitative relationships and differences will be illustrated by way of percentages, means, standard deviations, and t-values.

It should be noted that the respondents were given special instructions. If local computer activities fell into more than one of the four categories, responses were to be placed in the category or associated with the dimension where they fit best. Any computer activity that did not appear to fit into any category or be associated with any of the four dimensions was to be considered as part of the category which fit that activity most closely.

Drill and Practice:

When considering drill and practice on previously learned materials (Table 10), classrooms at the upper elementary school level (M=1.8, SD=0.8) engaged in significantly more ($t=9.5$, $p<0.001$) of this activity than classrooms at the lower grade levels (M=1.5, SD=0.6). These data reflect that on the average, elementary school pupils spend between zero to 30 minutes per week working on computer programs featuring science drill and practice activities. At the lower grade levels 54% of the classrooms do not have pupils working on drill and practice programs at all; at the upper grade levels 89% of the classrooms are represented by a total lack of or only up to 30 minutes per week of computer drill and practice time. A possible explanation for these results is the lack of microcomputers in the elementary school. There are no schools

TABLE 10

COMPUTER APPLICATIONS FOR SCIENCE TEACHING

Reactions / Minutes/Week	Grades K-2		Grades 3-5		t-value	p
	M	SD	M	SD		
Practice Previously Learned Material	1.5	0.6	1.8	0.8	9.5	0.001
Learn New Material	1.4	0.6	1.7	0.7	7.6	0.001
Learn by Computer Simulation	1.3	0.6	1.6	0.7	9.4	0.001
Develop Problem Solving and/or "Higher Level" Thinking Skills	1.4	0.6	1.7	0.8	8.5	0.001

Rating Scale

1	2	3	4	5
not at all	1 to 30 minutes	31 to 60 minutes	61 to 120 minutes	more than 120 minutes

where pupils spend more than 120 minutes per week in computer drill and practice exercises.

Learning New Materials:

The introduction of new science information by way of the computer (Table 10) occurred significantly more often ($t=7.6$, $p<0.001$) at the upper elementary school grades ($M=1.7$, $SD=0.7$) than at the lower grade levels ($M=1.4$, $SD=0.6$). When considering all grade levels, little (up to 30 minutes) or no time per week was spent learning new science material by way of the computer. Some 60% of the teachers at the lower grade levels and 45% of the upper level teachers do not use computer-driven science informational programs. Approximately 91% of all teachers at all grade levels either do not use informational materials or if they do, it does not exceed 30 minutes per week.

Simulation Exercises:

Many computer simulations of science processes are currently available. Examples include the flow of blood in the human body, the food web in a lake, life cycle of a frog, reproduction of a cell, etc. Computer simulations of science processes took place (Table 10) at the upper elementary school level ($M=1.6$, $SD=0.7$) significantly more often ($t=9.4$, $p<0.001$) than they did in lower grade classrooms ($M=1.3$, $SD=0.6$). It should also be noted that simulation software was used less often then drill and practice software. This might be attributed to the higher cost of commercial simulation programs. A second viable explanation is that simulations usually require more explanation by the teacher and thus are viewed as harder to use than drill and practice programs. At the lower grade levels, 74% of the classrooms surveyed provided no science simulation programs whereas about half (53%) of the upper elementary school classrooms provided no science computer simulations. There are no elementary schools where pupils are involved with computer simulation software more than 120 minutes per week.

Problem Solving Episodes:

The development of higher-order thinking skills by way of computer-driven problem solving programs is the focus of this dimension (Table 10). Classrooms at the upper grade levels (M=1.7, SD=0.8) participated in a significantly greater (t=8.5, p<0.001) amount of computerized problem solving activities than their counterparts at the lower grade levels (M=1.4, SD=0.6). These data reveal that problem solving episodes delivered by way of microcomputers occurs somewhere between not at all and 1 to 30 minutes per week. At the lower grade levels 63% of the classrooms and 45% of the classrooms at the upper grade levels do not engage in any computerized problem solving activities. No classrooms at either level engaged in more than 120 minutes per week of problem solving activities delivered by way of the computer.

Additional Commentary

Although there is currently little emphasis on computer applications for science teaching in the elementary school, there is some light at the end of the tunnel. Much of the lack of activity can be attributed to the absence of microcomputers in many elementary schools, especially at the lower grade levels. Software quality, often thought to be a barrier to computer utilization, was rarely noted as a problem in the comments section of the instrument. This result coincides with that of Becker (1986) who reported that poor quality software was not nearly as much of a problem as was lack of equipment.

In terms of the four science-oriented computer applications, the classrooms at the upper grade levels experienced significantly greater activity in all four areas when compared to the lower grade levels. The areas of greatest discrepancy between the levels were the use of drill and practice software and science simulation programs. The application which enjoyed the most utility at both levels was drill and practice, and the application receiving the least attention was the use of science simulations. These findings are consistent with those of Elron (1987) who urged greater use of simulation programs. In addition, these results are similar to those of Dickey and Kherlopian (1987) who found that tutorial, simulation, and problem solving software were used in some classrooms, but not used in many others.

Students use computers to learn science infrequently in the upper elementary school grades and rarely in the lower grade levels. Studies comparing lower to upper grade use of microcomputers were not found in the literature. The current finding of significantly greater computer use at the upper level, however, is understandable as pupils in the upper elementary grades are better readers, and thus more able to use computer software without extensive assistance.

Finally, it is safe to assume that computers are currently available in most elementary schools (Becker, 1986). Rather than just programming activities, they are being used to teach and practice science subject matter which was formerly presented through lecture or printed material. Simulation and problem-solving software guide pupils into critical thinking about topics not frequently addressed before computers were available. The objective of taking full advantage of microcomputers for science instruction has yet to be attained, but progress appears to be at a faster pace than may have originally been expected.

Results: Inservice - Mathematics and Science

The two areas of attention for inservice preparation were: (1) the use of hands-on manipulatives for problem solving and (2) computer-assisted or managed instruction. The findings have been analyzed by way of the upper grade levels

TABLE 11

INSERVICE PREPARATION FREQUENCY FOR SCIENCE AND MATH

Teaching Areas \ Inservice Areas	Hands-On Manipulations and/or Problem Solving		Computer-Assisted or Managed Instruction	
Science				
Grades K-2				
Mean	2.14		2.17	
SD	1.23		1.22	
Grades 3-5				
Mean	2.15		2.24	
SD	1.22		1.21	
t-value		0.3		3.5
Significance Level		0.7(ns)		0.001
Math				
Grades K-2				
Mean	2.42		2.62	
SD	1.30		1.27	
Grades 3-5				
Mean	2.42		2.64	
SD	1.29		1.25	
t-value		0.1		1.2
Significance Level		0.9(ns)		0.2(ns)
Science vs. Math				
Science				
Mean	2.14		2.21	
SD	1.07		1.20	
Math				
Mean	2.42		2.63	
SD	1.28		1.24	
t-value		3.1		4.6
Significance Level		0.001		0.001

that overwhelming, math sessions were conducted two or more times per semester in 10% of the elementary schools surveyed whereas science inservice was occurring only in about 6% of the elementary schools. At the less positive end of the spectrum, approximately 44% of the elementary schools reported that science inservice occurred less than once every two years whereas 35% signified that math inservice took place during the same time interval.

Computer-Based Instruction:

The frequency of computer-assisted or managed instruction (Table 11) inservice preparation session is little more promising. In view of science activities teachers at the upper grade levels (M=2.24, SD=1.21) engaged in significantly more ($t=3.5$, $p<0.001$) computer-oriented workshops than lower grade level teachers (M=2.17, SD=1.22). These data indicated that science-related computer-assisted or managed instruction inservice activities were engaged in once every two years to once a year. Somewhat astonishing is that 43% of the schools at the lower level and 39% at the upper grade levels reported that teachers have engaged in science-computer inservice less than once every two years, where 5% at all grades participated in two or more inservice sessions per semester.

Turning to the mathematics side of the coin (Table 11), both the lower grades (M=2.62, SD=1.27) and the upper grades (M=2.64, SD=1.25) teachers participated in math/computer inservice preparation at about the same frequency. No significant differences were found between the two groups. These figures represent computer inservice occurring at all grade levels about once a year. At all grade levels some 23% of the schools reported that math/computer inservice activities occurred one to two or more times per semester.

A comparison (Table 11) between the availability of science and math computer activities witnessed math inservice preparation (M=2.63, SD=1.24) occurring significantly ($t=4.6$, $p<0.001$) more often than science inservice preparation ($M=2.21$, $SD=1.20$). In the areas of science at all grade levels approximately 40% of the schools reported the presence of computer-related inservice preparation occurring less than once in every two years, whereas for math the infrequent event was associated with 25% of the respondents. At the more frequent end of the spectrum 9% of the teachers received math-computer inservice two or more times per semester whereas for the same time interval science was reported by only 6% of the schools.

Conclusions

On the average teachers received inservice instruction on the use of manipulatives for teaching problem solving once every one to two years. Inservice preparation on computer use in the teaching of science also took place every one to two years. Inservice workshops on these topics in mathematics occurred somewhat more often. In both subject areas and for both workshop topics lower grade level teachers (K-2) experienced less (and in some instances significantly less) workshop activity than upper grade level teachers (3-5). This may be attributed to several factors such as less sophisticated teaching content, a more integrated approach to content delivery, teacher apprehensiveness about engaging in inservice activities, and a lack of or fewer microcomputers physically stationed in lower grade level classrooms.

When considering the two topical areas, in all cases and at both grade levels, computer-oriented workshops were more popular than inservice activities focusing on the use of manipulatives to facilitate problem solving. Much of this can be probably attributed to the massive push for and bandwagon presence of microcomputers. In addition, both federal and state levels grants have been readily available for inservice preparation with respect to microcomputers at the local school system, regional and/or statewide levels.

The continuous professional growth and development of elementary school teachers needs to be addressed. Emphasis on career-long preparation really needs to be stressed at the undergraduate or preservice level. Interdisciplinary approaches might be emphasized in methods courses and in the cognate mathematics and science areas. At the inservice level teacher certification policies in many states need to be re-examined and updated. Despite much of the chaos and the perceived dysfunctionality associated with inservice education, many mathematics and science educators feel that the time has come to address these identified inservice problem areas because most elementary school teachers are fairly well entrenched at their jobs, possess tenure, and are permanently certified. More than half of the elementary classroom teachers have master's degrees; inservice professional development is a potential way to ward off obsolescence, mediocrity, stagnation, and a lack of what is new.

General Conclusions

When interpreting the results of this study, several limitations of the methodology must be kept in mind. First of all, the population sampled was elementary school principals. While principals are supposed to be the instructional leaders of their schools, the extent to which they are able to answer questions about the practices of their teachers varies considerably. The fact that there were no statistically significant differences in the response patterns of teachers and principals on the questionnaires indicates that, on the average, the principals responded to the instrument in the same way that teachers did. In general, data of the type collected in this study are very good for determining whether or not there are differences between grade levels or between mathematics and science on the questions asked. Mean responses to specific questions must, however, be treated cautiously.

Another point that needs to be kept in mind is that data reported here are intended as general indicators of trends in manipulatives, problem solving, and computers. There are certainly many classrooms where far more is going on in these areas than would be expected by looking at the results reported in this document. Unfortunately, there are many classrooms where there is little activity with respect to manipulatives, problem solving or computers. The high rate of return on the questionnaires for this study does indicate that all findings are generalizable throughout Indiana.

Perhaps the most intriguing finding of this study is that principals report that science, in some form, is taught in most elementary school classrooms in the Indiana. One must view this result with caution as there is little information available about what type of science is being taught. It is possible that a science lesson could consist of a few minutes of reading from a science text each week with little or no hands-on involvement by students. The fact that principals report that science is being taught in some fashion is reason for optimism, however, as science has often been thought of as unimportant for elementary school students.

At the time the current study was started, a major question was whether or not manipulatives were being used in elementary schools. Data from the study indicate that most teachers have access to manipulative materials in mathematics and science and do use them several times per month. An open question is the extent to which teachers have enough materials or the proper types. A related unanswered question is whether teachers use materials as they were intended.

The extent to which problem solving and critical thinking are important goals of the elementary school was also an open question when this study was started. The data collected indicate that principals and teachers see problem solving as an important goal in the elementary school, although, on the average, it does not appear to be as important as development of "basic skills". Again, the fact that problem solving was generally felt to be important is a sign that school personnel see education as encompassing more than the teaching of memorized facts.

Computer related findings of this study were about as expected. Drill and practice is the predominant form of computer use although some teachers are beginning to find more creative uses of this technology. Computers are utilized in most classrooms, although not to the extent that they could be.

Clearly, teachers and principals are realizing that they can no longer ignore computers and are learning enough about them to use them in some capacity.

In summary, manipulatives, problem solving, and computers were reported to be at least somewhat important factors in mathematics and science instruction by the vast majority of individuals responding to the survey. Schools change slowly and thus it will take time for these changes to be implemented completely. The data from this study indicate that change has begun in Indiana but we still have a long way to go.

References

An agenda for action. (1980). Rest n, VA: National Council of Teachers of Mathematics.

Andersen, D. (1983). The development, implementation and evaluation of an in-service workshop in computer literacy and awareness for educators (Doctoral dissertation, University of Northern Colorado, 1983). Dissertation Abstracts International, 44, 2339A.

Baratta-Lorton, M. (1976). Mathematics their way. Menlo Park, CA: Addison-Wesley.

Beall, D., & Harty, H. (1984). Inservice teachers reactions to implementing microcomputers in elementary science and mathematics classes. Journal of Computers in Mathematics and Science Teaching, 3, 34-38.

Becker, H. J. (1986). Our national report card: Preliminary results from the new Johns Hopkins survey. Classroom Computer Learning, 6(4), 30-33.

Bell, F. H. (1979). Computer literacy, school mathematics, and problem solving: Three for the price of one. Association for Educational Data Systems Journal, 12, 163-170.

Bracey, G. (1982). Computers in education: What the research shows. Electronic Learning, 2, 51-54.

Bratt, M. (1983). Microcomputers in elementary science education. School Science and Mathematics, 83, 333-337.

Bruni, J. V. (1982). Problem solving for the primary grades. Arithmetic Teacher, 30(6), 10-15.

Carpenter, T. P., Matthews, W., Lindquist, M. M., & Silver, E. A. (1984). Achievement in mathematics: Results from the national assessment. The Elementary School Journal, 84, 485-495.

Charles, R., Lester, F., & O'Daffer, P. (1987). How to evaluate progress in problem solving. Reston, VA: National Council of Teachers of Mathematics.

Charles, R. I., & Lester, F. K. (1985). Problem-solving experiences in mathematics. Menlo Park, CA: Addison-Wesley.

Charles, R. I., & Lester, F. K. (1984). An evaluation of a process-oriented instructional program in mathematical problem solving in grades 5 and 7. Journal for Research in Mathematics Education, 15, 15-34.

Cohen, M. (1979). Improving teachers' conceptions of computer assisted instruction. Educational Technology, 19, 32-33.

Dickerson, L, & Pitchard, W. (1981). Microcomputers and education: Planning for the coming revolution in the classroom. Educational Technolgoy, 21, 7-12.

Dickey, E., & Kherlopian, R. (1987). A survey of teachers of mathematics, science, and computers on the uses of computers in grades 5-9 classrooms. Educational Technology, 27(6), 10-14.

Driscoll, M. J. (1980). Research within reach: Elementary school mathematics. Reston, VA: National Council of Teachers of Mathematics.

Eiser, L. (1986). Problem-solving software: What it really teaches. Classroom Computer Learning, 6(5), 42-45.

Elron, O. (1983). Teaching with computer simulations. Science and Children, 20(8), 13-17.

Fennema, E. H. (1972). Models and mathematics. Arithmetic Teacher, 19, 635-640.

Fey, J. T. (1979). Mathematics teaching today: Perspectives from three national surveys. Arithmetic Teacher, 27(2), 10-14.

Filliman, P. (1983). Guidelines for introducing microcomputers in the schools. Arithmetic Teacher, 30, 16-17.

Fisher, F. D. (1982). Computer-assisted education: What's not happening. Journal of Computer-Based Instruction, 9, 19-27.

Fuller, K. (1986). Beyond drill and practice: Using computers to build hypotheses and design and conduct experiments. Science and Children, 23(7), 9-12.

Glass, E. M. (1984). Computers: Challenge and opportunity. In V. P. Hansen & M. J. Zweng (Eds.), Computers in mathematics education (pp. 10-14). Reston, VA: National Council of Teachers of Mathematics.

Hansen, V. P. (Ed.). (1984). Computers in mathematics education. Reston, VA: National Council of Teachers of Mathematics.

Harty, H., & Enochs, L. G. (1985). Toward reshaping the inservice education of science teachers. School Science and Mathematics, 85, 125-135.

Hatfield, L. L. (1984). Toward comprehensive instructional computing in mathematics. In V. P. Hansen & M. J. Zweng (Eds.), Computers in mathematics education (pp. 1-9). Reston, VA: National Council of Teachers of Mathematics.

Heck, W. P., Johnson, J., & Kansky, R. J. (1981). Guidelines for evaluating computerized instructional materials. Reston, VA: National Council of Teachers of Mathematics.

Heddens, J. W. (1986). Bridging the gap between the concrete and the abstract. Arithmetic Teacher, 33(6), 14-17.

Herbert, E. (1985). Manipulatives are good mathematics! Arithmetic Teacher, 32(6), 4.

Impact of computing technology on school mathematics: Report of an NCTM conference. (1985). Arithmetic Teacher, 32(8), 14-18.

Kloosterman, P., Ault, P. C., & Harty, H. (1987). School-based computer education: Practices and trends. Educational Technology, 27(4), 35-38.

Larson, C. N., & Slaughter, H. (1984). The use of manipulatives and games in selected elementary school classrooms, from an ethnographic study. Focus on Learning Problems in Mathematics, 6(1), 31-49.

Leeb-Lundberg, K. (1985). Mathematics is more than counting. Wheaton, MD: Association for Childhood Education International.

Long, C. (1985). How are today's elementary schools using computers? Educational Technology, 25(5), 27-29.

Milner, S. (1980). Teaching teachers about computers: A necessity for education. Phi Delta Kappan, 61, 544-546.

Nibbelink, W., & Shepardson, R. D. (1985). Problem-solving sourcebook: Invitation to mathematics. Glenview, IL: Scott, Foresman.

Norton, P. (1985). Problem-solving activities in a computer environment: A different angle of vision. Educational Technology, 25(10), 36-41.

Osborne, A., & Kasten, M. B. (1980). Opinions about problem solving in the curriculum for the 1980's: A report. In S. Krulik & R. E. Reys (Eds.), Problem solving in school mathematics (pp. 51-60). Reston, VA: National Council of Teachers of Mathematics.

Parham, J. L. (1983). A meta-analysis of the use of manipulative materials and student achievement in elementary school mathematics (Doctoral dissertation, Auburn University, 1983). Dissertation Abstracts International, 44, 96A.

Ponte, J., Norman, F. A., Davis, E. J., Eshun, B. A., & Jensen, R. J. (1986). Evaluation of an instructional computing inservice course for elementary and middle school teachers. School Science and Mathematics, 86(5), 375-385.

Post, T. R. (1980). The role of manipulative materials in the learning of mathematical concepts. In M. M. Lindquist (Ed.), Selected issues in mathematics education (pp. 109-131). Berkeley, CA: McCutchan.

Romberg, T. A. (1984). School mathematics: Options for the 1990's. Washington, DC: Office of Educational Research and Improvement.

Sadowski, B. (1983). A model for preparing teachers to teach with the microcomputer. Arithmetic Teacher, 30, 24-25.

Scott, W. A. (1955). Reliability of content analysis: The case of nominal scale coding. Public Opinion Quarterly, 19, 321-325.

Seidman, S. A. (1986). A survey of schoolteachers' utilization of media. Educational Technology, 26(10), 19-23.

Stake, Robert E., & Easley, J. (Eds.). (1978). Case Studies in Science Education. Urbana, IL: University of Illinois.

Suydam, M. N. (1984). Manipulative materials. Arithmetic Teacher, 31(4), 27.

Suydam, M. N., & Higgins, J. L. (1977). Activity-based learning in elementary school mathematics: Recommendations from research. Columbus, OH: ERIC/SMEAC.

Westley, J. E. (1985). Textbooks go hi-tech. Classroom Computer Learning, 5(5), 42-49.

Wheatley, C. L., & Wheatley, G. H. (1984). Problem solving in the primary grades. Arithmetic Teacher, 31(3), 22-25.

Williams, D. E. (1987). A calculator-integrated curriculum: The time is now. Arithmetic Teacher, 34(6), 8-9.

APPENDIX A

Indiana Statewide Elementary School Math and Science
Needs Assessment Inventories

INDIANA UNIVERSITY

SCHOOL OF EDUCATION
Education Building
3rd and Jordan
Bloomington, Indiana 47405

November 21, 1986

Dear Elementary School Principal:

Indiana University and the Indiana Association of Elementary and Middle School Principals jointly are conducting a study of mathematics and science teaching in Indiana elementary schools. The study, funded in part by the Indiana Department of Education, is a follow-up to a study of high school teaching of mathematics and science which has just been completed. The enclosed questionnaire will provide valuable data about elementary school mathematics and science in Indiana, so we ask you to complete it honestly and accurately by *December 12, 1986*. Completing the questionnaire should only take 10 to 15 minutes.

Many of the items on the questionnaire deal with use of "hands-on" manipulatives/ physical models in the classroom. By "hands-on" manipulatives, we are referring to objects such as counting blocks, Cuisenaire rods, balances, thermometers, physical models, etc. which the students themselves use. Pictures or objects which are used only by the teacher for demonstration purposes should not be considered manipulatives when you are completing this survey.

If you are unsure about how to answer some of the questions on the enclosed questionnaire, it may be useful to take a minute at a staff meeting to poll your teachers for the information you need to complete the items. If you think one or more of your teachers or curriculum coordinators could answer the questions more accurately than you, please ask that person, or persons, to complete the questionnaire. As this survey is being sent only to a limited sample of administrators in Indiana, it is important that we get complete and honest responses from every school that has received a questionnaire. Feel free to call Dr. Kloosterman or Dr. Harty if you have questions. We thank you in advance for your cooperation.

Sincerely,

H Dean Evans — Harold Harty — Peter Kloosterman — Don M. Small

Dr. H. Dean Evans	Dr. Harold Harty	Dr. Peter Kloosterman	Dr. Don M. Small
State Superintendent of Public Instruction	Professor of Science Education	Assistant Professor of Mathematics Education	Executive Director
Indiana Department of Education	Indiana University	Indiana University	Indiana Association of Elementary and Middle School Principals
	(812) 335-2720	(812) 335-2546	
	(812) 335-7184	(812) 335-4702	

INDIANA STATEWIDE ELEMENTARY SCHOOL MATH AND SCIENCE NEEDS ASSESSMENT INVENTORY

School Code No.: ______________

____
(Person(s) Filling Out Inventory)

____
Title(s)

Return to: Indiana Needs Analysis Project
337 - Education Building
Indiana University
Bloomington, IN 47405

Directions: Below are several statements and/or questions seeking information about elementary school mathematics and science teaching-learning. There are no correct or incorrect responses to the items. Your unbiased and frank reactions based on your observations and perceptions will truly be appreciated. Your responses should represent the average/typical classroom in your school. Please indicate your reaction by placing the NUMBER that represents your collective thoughts on the LINE provided in the RIGHT HAND MARGIN. Your responses will remain CONFIDENTIAL. Thank you in advance for your cooperation.

- *What percentage of your teachers have commercially-made "hands-on" materials/manipulatives/physical models available for use in your school:*

1	2	3	4	5
less than 10%	10% to 39%	40% to 60%	61% to 89%	90% to 100%

Mathematics (base-ten blocks, Cuisenaire rods, attribute blocks, pattern blocks, etc.)

Grades K thru 2 — 1. ______

Grades 3 thru 5 — 2. ______

Science (thermometer, balance, candles, live specimens, etc.)

Grades K thru 2 — 3. ______

Grades 3 thru 5 — 4. ______

- *What percentage of your teachers have teacher-made or teacher-collected "hands-on" materials/manipulatives/physical models available for use in your school:*

1	2	3	4	5
less than 10%	10% to 39%	40% to 60%	61% to 89%	90% to 100%

<u>Mathematics</u> (counting sticks, bead sticks, blocks, buttons, cardboard shapes, etc.)

Grades K thru 2 5. ______

Grades 3 thru 5 6. ______

<u>Science</u> (leaf collection, tin cans, insect collection, jars, rock collection, rope, paper bags, etc.)

Grades K thru 2 7. ______

Grades 3 thru 5 8. ______

- *About how many <u>days per school year</u> do pupils use "hands-on" materials/manipulatives/physical models (commercial or teacher-made):*

	2	3	4	5
less than 10	10 to 21	22 to 41	42 to 89	90 or more

<u>Mathematics</u>

Grades K thru 2 9. ______

Grades 3 thru 5 10. ______

<u>Science</u>

Grades K thru 2 11. ______

Grades 3 thru 5 12. ______

- *<u>When</u> "hands-on" materials/manipulatives/physical models (commercial or teacher-made) are used in the classroom, to what extent are they used to help pupils "learn the rules" for computation, measuring, estimating, etc. rather than understand how or why these rules work:*

0	1	2	3	4	5
unable to answer	not used at all	rarely, once in a great while	sometimes but not often	often but not always	most if not all of the time

Mathematics (manipulatives used to increase speed for computations, memorize basic facts, learn definitions, etc.)

Grades K thru 2 13. ______

Grades 3 thru 5 14. ______

Science (learn the rules for graphing, operationally defining, variable identification, classification, etc)

Grades K thru 2 15. ______

Grades 3 thru 5 16. ______

- *When "hands-on" materials/manipulatives/physical models (commercial or teacher-made) are used in the classroom, to what extent are they used to get pupils to understand broad concepts or to solve problems which require substantial creative thinking:*

0	1	2	3	4	5
unable to answer	not used at all	rarely, once in a great while	sometimes but not often	often but not always	most if not all of the time

Mathematics (manipulatives used to understand computational procedures, understand multi-step story problems, apply computations to real life problems, understand pattern questions, solve logic problems, etc.)

Grades K thru 2 17. ______

Grades 3 thru 5 18. ______

Science (materials used for explaining inductive and deductive approaches, setting up controlled experiments, doing science fair projects, etc.)

Grades K thru 2 19. ______

Grades 3 thru 5 20. ______

- *How much did (will) your school look for texts that use "hands-on" materials/manipulatives/physical models in your most recent (current) textbook selection:*

0	1	2	3	4	5
unable to answer	was not a factor	considered occasionally	considered often	considered extensively	was the main factor

Mathematics

Grades K thru 2 21. ______

Grades 3 thru 5 22. ______

Science

Grades K thru 2 23. ______

Grades 3 thru 5 24. ______

- *On the average how many minutes per week are devoted to the "hands-on" and "non-hands-on" teaching of science and mathematics in each classroom:*

1	2	3	4	5
None	1 to 59 minutes	60 to 119 minutes	120 to 240 minutes	more than 240 minutes

HANDS-ON

Mathematics

Grades K thru 2 25. ______

Grades 3 thru 5 26. ______

Science

Grades K thru 2 27. ______

Grades 3 thru 5 28. ______

NON-HANDS-ON: (All Teaching Except Hands-On)

Mathematics

Grades K thru 2 29. ______

Grades 3 thru 5 30. ______

Science

Grades K thru 2 31. ______

Grades 3 thru 5 32. ______

COMMENTS (Optional): ______________________________

Thank you!

INDIANA UNIVERSITY

SCHOOL OF EDUCATION
Education Building
3rd and Jordan
Bloomington, Indiana 47405

November 21, 1986

Dear Elementary School Principal:

Indiana University and the Indiana Association of Elementary and Middle School Principals jointly are conducting a study of mathematics and science teaching in Indiana elementary schools. The study, funded in part by the Indiana Department of Education, is a follow-up to a study of high school teaching of mathematics and science which has just been completed. The enclosed questionnaire will provide valuable data about elementary school mathematics and science in Indiana, so we ask you to complete it honestly and accurately by *December 12, 1986*. Completing the questionnaire should only take 10 to 15 minutes.

Some of the items on the questionnaire deal with the implementation of a problem solving/thinking skills curriculum. By "problem solving" and "thinking skills" we are referring to the development of the skills needed to solve problems which cannot be solved easily with a step-by-step procedure. Mathematical word problems for which key words are not very useful would be considered problem solving, as would science activities which focus on the development of concepts and principles as opposed to skill activities such as correctly using a balance.

If you are unsure about how to answer some of the questions on the enclosed questionnaire, it may be useful to take a minute at a staff meeting to poll your teachers for the information you need to complete the items. If you think one or more of your teachers or curriculum coordinators could answer the questions more accurately than you, please ask that person, or persons, to complete the questionnaire. As this survey is being sent only to a limited sample of administrators in Indiana, it is important that we get complete and honest responses from every school that has received a questionnaire. Feel free to call Dr. Harty or Dr. Kloosterman if you have questions. We thank you in advance for your cooperation.

Sincerely,

H Dean Evans
Dr. H. Dean Evans
State Superintendent
of Public Instruction
Indiana Department
of Education

Harold Harty
Dr. Harold Harty
Professor of
Science Education
Indiana University
(812) 335-2720
(812) 335-7184

Peter Kloosterman
Dr. Peter Kloosterman
Assistant Professor of
Mathematics Education
Indiana University
(812) 335-2546
(812) 335-4702

Don M. Small
Dr. Don M. Small
Executive Director
Indiana Association
of Elementary and
Middle School
Principals

INDIANA STATEWIDE ELEMENTARY SCHOOL MATH AND SCIENCE NEEDS ASSESSMENT INVENTORY

School Code No.: ______________

____
(Person(s) Filling Out Inventory)

____
Title(s)

Return to: Indiana Needs Analysis Project
337 - Education Building
Indiana University
Bloomington, IN 47405

Directions: Below are several statements and/or questions seeking information about elementary school mathematics and science teaching-learning. There are no correct or incorrect responses to the items. Your unbiased and frank reactions based on your observations and perceptions will truly be appreciated. Your responses should represent the average/typical classroom in your school. Please indicate your reaction by placing the NUMBER that represents your collective thoughts on the LINE provided in the RIGHT HAND MARGIN. Your responses will remain CONFIDENTIAL. Thank you in advance for your cooperation.

- *To what extent is your curriculum geared toward problem solving and understanding of broad concepts as opposed to "following the rules" to complete a computation or get an answer to a science question? An emphasis on problem solving and the understanding of broad concepts exists:*

0	1	2	3	4	5
unable to answer	practically never	once in a great while	sometimes	fairly often	very often

Mathematics (understanding of place value and multi-step story problems, applying math to real life problems, solving logic problems, etc.)

Grades K thru 2 — 1. ______

Grades 3 thru 5 — 2. ______

Science (understanding concepts such as cell, wind, autumn, sound, etc.)

Grades K thru 2 — 3. ______

Grades 3 thru 5 — 4. ______

- *Approximately how many minutes per week do students spend on activities designed to foster "higher level" thinking skills:*

0	1	2	3	4	5
unable to answer	none	1 to 59 minutes	60 to 119 minutes	120 to 240 minutes	more than 240 minutes

<u>Mathematics</u> (applying math concepts to new situations, solving pattern problems, understanding of fractional parts, etc.)

Grades K thru 2 5. ______

Grades 3 thru 5 6. ______

<u>Science</u> (applying science concepts to new situations, learning about inductive and deductive approaches, creating controlled experiments, etc).

Grades K thru 2 7. ______

Grades 3 thru 5 8. ______

- *How often do teachers bring in activities beyond those found in the textbook that promote problem solving and the development of "higher order" thinking skills:*

0	1	2	3	4	5
unable to answer	almost never	one to three times/month	four to six times/month	seven to nine times/month	ten or more times/month

<u>Mathematics</u>

Grades K thru 2 9. ______

Grades 3 thru 5 10. ______

<u>Science</u>

Grades K thru 2 11. ______

Grades 3 thru 5 12. ______

- *How much of a factor were (are) the teaching of problem solving and promoting the development of thinking skills in your most recent (current) textbook selection:*

0	1	2	3	4	5
unable to answer	were not factors	considered occasionally	considered often	considered extensively	were the main factors

<u>Mathematics</u>

Grades K thru 2 13. ______

Grades 3 thru 5 14. ______

<u>Science</u>

Grades K thru 2 15. ______

Grades 3 thru 5 16. ______

* * * (SPECIAL NOTE) * * *

The following questions are about computer activities in mathematics and science. If some computer activities fall into more than one of the following four categories, respond to them only in the category where they fit best. Any computer activity that doesn't seem to fit into any category should be considered as part of the category which fits that activity most closely.

- *How many minutes per week will an average pupil use the computer (alone or in a small group) to:*

1	2	3	4	5
not at all	1 to 30 minutes	31 to 60 minutes	61 to 120 minutes	more than 120 minutes

1. PRACTICE PREVIOUSLY LEARNED MATERIALS

Mathematics

Grades K thru 2 17. _______

Grades 3 thru 5 18. _______

Science

Grades K thru 2 19. _______

Grades 3 thru 5 20. _______

2. LEARN NEW INFORMATION OR SUBJECT MATTER

Mathematics

Grades K thru 2 21. _______

Grades 3 thru 5 22. _______

Science

Grades K thru 2 23. _______

Grades 3 thru 5 24. _______

3. LEARN BY WAY OF A COMPUTER SIMULATION

Mathematics ("operate" a lemonade stand, "run" a store, etc.)

Grades K thru 2 25. _______

Grades 3 thru 5 26. _______

Science (flow of a drop of blood in the human body, life cycle of a frog, reproduction of a cell, etc.)

Grades K thru 2 27. _______

Grades 3 thru 5 28. _______

4. ATTEMPT TO DEVELOP PROBLEM SOLVING AND/OR HIGHER ORDER THINKING SKILLS

Mathematics

Grades K thru 2 29. ______

Grades 3 thru 5 30. ______

Science

Grades K thru 2 31. ______

Grades 3 thru 5 32. ______

- *Inservice training/preparation is available to teachers in the areas of:*

1	2	3	4	5
less than once every two years	once every two years	once a year	once a semester	two or more times per semester

HANDS-ON MANIPULATIVES AND/OR PROBLEM SOLVING

Mathematics

Grades K thru 2 33. ______

Grades 3 thru 5 34. ______

Science

Grades K thru 2 35. ______

Grades 3 thru 5 36. ______

COMPUTER ASSISTED OR MANAGED INSTRUCTION

Mathematics

Grades K thru 2 37. ______

Grades 3 thru 5 38. ______

Science

Grades K thru 2 39. ______

Grades 3 thru 5 40. ______

COMMENTS (optional):

Thank you!